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International Asia Conference on Industrial Engineering and Management Innovation (IEMI2012) Proceedings

Core Areas of Industrial Engineering

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Contents

Chapter 1
A Study on Improvement Design Based on TRIZ and Extension Method

Fong-gong Wu, Jung-fu Lee, Chang-tzuoh Wu, Ming-tang Wang and Shi-liang Luo

Abstract This research focuses on developing an approach to innovative design problems based on the TRIZ and extension method. The proposed innovative design procedure combines the Su-Field modeling procedure, contradiction matrix and extension method to improve the efficiency and extent of concept evolutions. The extensibility of matter-element can be used to exchange the descriptions of design problems and solutions into creative fields. In this research, we will introduce the TRIZ contradiction matrix and concept extension of matter-element into symbolic developments to derive out more creative solutions. This study proposes a flexible and extensible innovative design approach with the help of extension method. The bicycle design examples are adopted to explain and verify the feasibility of the proposed approach. The case study successfully demonstrates that the proposed approach is feasible and efficient.

Keywords Bicycle · Contradiction matrix · Extension theory · Matter-element · Su-field

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1.1 Introduction

TRIZ is TIPS (Theory of Inventive Problem Solving) Russian synonym word, it means whether it is the methods of question to answer, Savransky (2002) think that TRIZ method is an answer based on human knowledge invents the question systems approach (Altshuller 2000). Altshuller, the father of TRIZ, has explained the deduction course innovated and invented in detail. Before cold war era between east and west, the research of TRIZ has been the state secret as Soviet Union. But TRIZ method is wide for western countries gradually know after the disintegration of the Soviet Union, and becomes the method that the extremely authoritative innovative problem solving. In the design process of innovation, limitation of designer's knowledge field, habitual thinking course, is the obstacle appeared in innovation procedure, especially using the open thinking methods. The TRIZ method can assists the designer in the concept development stage to expand to the knowledge domain that oneself is not skillful at, and has provided a systematic design procedure to define the design problem more distinct and get the innovative idea in design processes.

The designers' abilities of innovation and problem solving play a key role in the research abilities of enterprises. Thus, developing the suitable innovative method become the most urgent need. Su-Field analysis, one of the major tools which the TRIZ method deducts, is a useful tool for identifying problems in a technical system and finding innovative solution to these identified problems. Using Su-Field analysis method can analyze and improve the function of the technological system. In the relevant research of the Su-field method, Terninko (2000) introduced the operating procedures of Su-field analysis model in detail. Some design examples successfully demonstrate that the Su-field analysis model and corresponding 76 standards solution by (Terninko 2000; Terninko et al. 2000). Mao et al. (2007) proposed that the 76 standard solutions can be summarized into seven general principles with graphic demonstrations and examples (Mao et al. 2007).

Most of the researcher, while using the Su-Field method to analysis effect relation between the system inner components, thought that the Su-Field analysis was still worth conducting the research. This research tries to introduce extensive into the Su-Field modeling procedure to improve the efficiency and extent of concept evolutions. Besides, contradiction matrix has also been used to modify the new concept. Through this research, we will try to build an explicit and feasible intelligent innovation processes and evaluation method progressively. The feasibility will also be verified through patents.

1.2 Extension Su-Field Analysis Method

Matter-element and extension method, a powerful tool to systematically analyze concrete or intangible products, has been developed by W. Cai in 1983. Extension Theory is a course to study the extensibility, extent rules, performing procedure of matter and try to employ to resolve contradictive problems.

The extension method was derived from the extension theory that involves the matter-element theory and extension mathematics. The major research subject of extension theory is incompatible problem in the real world. Its applications and research have already extended to each field, including business, management, engineering, economics, sociology, strategy, etc. (Wang and Zhao 1998; Cai 1994; Cai et al. 1997).

1.2.1 Symbolic System of Su-Field Model

According to TRIZ, the rationale of creating a Su-Field model is that a system, with the ultimate objective to achieve a function, normally consists of two substances and a field. The term S_1 is used to represent an object that needs to be manipulated. The term S_2 is a tool to act upon S_1. The term field (F) includes the fields of physics (that is, electromagnetism, gravity, strong and weak nuclear interactions). A field provides some flow of energy, information, force, interaction, or reaction to perform an effect. Altshuller graphically represent a Su-field model as a triangle. This is a simple and ingenious way to explain a technical system. (See Fig. 1.1.)

Other possible states are: The effect needed has not taken place, caused harmful effect and required effects are insufficient. Besides, in technological conflict, the connecting effects are: 1. conflict between two subsystems in a system; 2. set up useful effect in a certain subsystem and lead to harmful effect in another subsystem; 3. dispel the harmful effect in a certain subsystem, cause the damage on the useful effect of another subsystem. 4. strengthen the useful function or reduce the harmful effect, cause unacceptable complication in system or another subsystem.

Usually, we focus on the components needed to be improved or with valueless function. Therefore, a fast and simple model will offer different thinking directions to a designer.

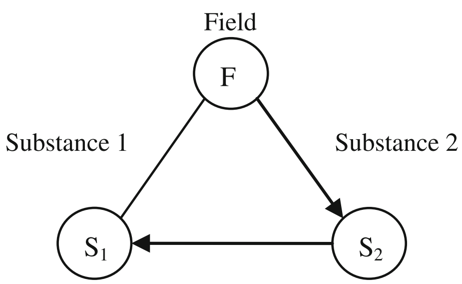

Fig. 1.1 A. Basic Su-field model (Terninko, 2000)

1.2.2 Extensive Procedures

This research will employ matter-element analysis and extension theory repeatedly; try to integrate "extension of matter-element" with the Su-Field modeling procedure to improve the efficiency and extent of concept evolutions. The stages are divided into to carry on,

(1) *First stage:* The extension method can help people resolve problems separately by decomposing them, recombining the problems, and then searching for the feasible solutions, assist the Su-field model to extend and deduce concepts widely.
(2) *Second stage:* While using the Su-Field method to realize innovative design, expansibility of matter-element can give extending design based on the advised solution providing by 76 standard solutions. Through the transformation, designers can conceive of other substituting matter-element models effectively and quickly to obtain various innovative design plans (Yan and Liu 2003; Yang and He 1999; Yang 1998).

The components, any of its characteristics can be changed, and the subsystem can be a component of a complete Su-Field. To solve a problem, the missing component is introduced to the incomplete Su-Field to make it complete. Even though the Su-field model is complete, model should be improved and modified while the connections between substances and field are harmful or insufficient. In addition, while dealing with more complicated design problem, Su-field model can be expanded to construct the various, multiple Su-Field triangles according to the scale of the question.

Obviously, by introducing the concept of matter-element and matter-element with multi-characteristics and regarding a substance of Su-field model as a matter-element, it will assist the creative thinking and innovation for problem solving. Matter-element and matter-element with multi-characteristics are defined as follows,

matter-element

$$R = (N(t),\ c,\ v(t)) \tag{1.1}$$

matter-element with multi-characteristics

$$\mathrm{R}(t) = \begin{bmatrix} \mathrm{N}(t) & c_1 & v_1(t) \\ & c_2 & v_2(t) \\ & \vdots & \vdots \\ & \mathrm{c}_n & v_n(t) \end{bmatrix} = (\mathrm{N}(t),\ \mathrm{C},\ \mathrm{V}(t)) \tag{1.2}$$

Based on the divergence of matter-element, matter-element R_0 (N_0, c_0, v_0) can be diverged from one or two of N_0, c_0, v_0 to synthesizing different matter-elements, to build an extending tree. Extending tree is a method for matter to extend outwards to provide multi-orientated, organizational and structural considerations.

An event, the interaction of matters, is described as event-element. Basic elements for an event-element are constructed by verb (d), name of verb characteristic (b) and u, the corresponding measure about (b).

Event-element

$$\mathrm{I}(t)=(\mathrm{d}(t),\ \mathrm{b},\ \mathrm{u}(t)) \tag{1.3}$$

Multi-dimensional event-element

$$I(t) = (\mathrm{d}(t),\ B,\ U(t)) \tag{1.4}$$

There may be different relations among a certain matter, event and other matters, events; there is interaction between these relations, influence each other. The corresponding matter-element, event-element and other matter-elements, event-elements can be used to describe these relationships and interactions. Relationship-element, a n-dimensional matrix, is form by relationship name s(t), characteristics $a_1,\ a_2,\ \ldots,\ a_n$ and corresponding measure values $w_1(t)$, $w_2(t)$, $\ldots$, $w_n(t)$:

$$\mathrm{Q}(t) = \begin{bmatrix} \mathrm{s}(t) & \mathrm{a}_1 & \mathrm{w}_1(t) \\ & \mathrm{a}_2 & \mathrm{w}_2(t) \\ & \vdots & \vdots \\ & \mathrm{a}_\mathrm{n} & \mathrm{w}_\mathrm{n}(t) \end{bmatrix} = (\mathrm{s}(t),\ \mathrm{A},\ \mathrm{W}(t)) \tag{1.5}$$

The extensible properties of matter-element, event-element and relationship-element, comprising: divergence, expansibility, relevance and implication. While solving design problems based on Su-field model, diversity and creativity, the advantages of "extenics" method will be imported by implementing the extensibility of matter-element, event-element and relationship-element. Thus, the solution will not be limited by standard solutions but be inspired (Lian and Zhang 1995; Zhao 1998; Zhao 2000).

1.3 Introducing Contradiction Matrix into Su-Field

While we effort to improve one system characteristic and degrade another one, contradiction often arises. The contradiction matrix has been introduced in TRIZ to solve a technical contradiction design problems. In this study, three important elements of Su-field model (subject S, field F and relationships) have been tried to correspond to the TRIZ contradiction matrix. As the Su-field model built, the elements needed to be improved are also identified. For the substances S, field F or states which needed to be modified, the corresponding engineering parameters can be determined by reference to the 39 engineering parameters. A technical conflict problem can be solved in two steps by using the contradiction matrix table (Table 1.1). At first, we analyze the attributes of the problem and determine the

Table 1.1 Partial cells of contradiction matrix

Worsening engineering parameters			9	10	11	12	
Improving engineering parameters		…	Speed	Force	Tension/pressure	Shape	…
	…						
9	Speed			13.28 15.19	06.18 38.40	35.15 18.34	
10	Force		13.28 15.12		18.21 11	10.35 40.34	
11	Tension/ pressure		06.35/36	36.35/21		35.04/15.10	
12	Shape		35.15 34.18	35.10 37.40	34.15 10.14		
13	Stability of object		33.15 28.18	10.35 21.16	2.35 40		
14	Strength		8.13 26.14	10.18 3.14	10.3 18.40		
	…						

parameter "feature to improve" in the columns and "undesired result" in the rows. Then, we attempt to resolve the conflict problem by using three or four recommend inventive principles that are listed in the intersecting cell. The inventive principles can be used to facilitate the development of useful "concepts of solution" (Ideation International Inc. 1999).

1.4 Illustrative Design Case

In this research, the proposed invention procedure is used to expand a design case "manpower drive vehicles". A traditional bicycle uses a chain for transferring the pedal actuated driving force from the pedal crankshaft to the rear wheel. After using period of time, the chain-link is prone to come off the ratchet and slip gears. In addition, the long skirt also has the risk that is sullied or rolled into chain link. Thus, "How to eliminate the use of the chain, but without affecting the function of transmission" will be the design problem.

1.4.1 List Su-Field Model Related to Design Problem

The initial Su-field model is constructed according to operation situation and function of the traditional bicycle. Su-field model of the traditional bicycle can be illustrated as follows. It is essential that the present Su-field model should be conformed to the design problem. It should be avoided illustrating a Su-field model that is irrelevant to the design problem. According to the traditional bicycle and biked processes, Su-field model can be constructed as Fig. 1.2a. S_1 represents the chain, S_2 represents front gear set. This description of Su-field model is that the front gear set (S_2) transmits pedal force (F_P) to the chain (S_1).

In order to prevent the inconvenience of the use of chain, the chain (S_1) is considered as the component that should be replaced. After eliminating it, this Su-field model becomes incomplete. Then, refer to 1st transformation rule, introduce a substance component (represent with S_1' here, in order to avoid confuse with the original material S_1) to fill up the vacancy of model, make it keep function that transmission. Similarly, the front gear set (S_2) should support the pedal force (F_P) to the substance (S'_1). After performing transformation, Su-field model is illustrated as Fig. 1.2b.

1.4.2 Extensive Procedures of Innovation Design

The following steps are to transfer Su-field model to design prototype:

(1) *Survey the entity component correlated to S'_1.* Exclude chain, we search for the replaceable subject by using the divergence of matter-element.
(2) *Use extending tree method to build the transformation model:* A matter refers to multi-characteristics, a characteristic also mapped by matters.
(3) *Transform the transmission device into a general model by the divergence tree of matter-element extension method.* The extension of matter-element, can be expressed as,

$$\begin{aligned} R_1 &= (\text{N, c}_1,\ \text{v}_n) \\ &= (\text{transmission device, flexible mechanism, chain}) \\ &= (\text{transmission device, flexible mechanism, belt}) \\ &= (\text{transmission device, flexible mechanism, rope})\ldots\text{etc.} \end{aligned}$$

$$\begin{aligned} R_2 &= (\text{N, c}_2,\ \text{v}_n) \\ &= (\text{transmission device, rigid mechanism, gear set}) \\ &= (\text{transmission device, rigid mechanism, linkage})\ldots\text{etc.} \end{aligned}$$

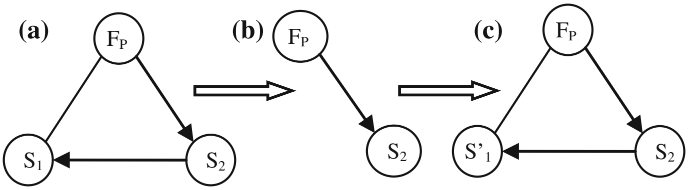

Fig. 1.2 **a** Su-field model of the traditional bicycle, **b** Incomplete model, **c** Add new substance to complete Su-field model

The extension of event-element,

$$I = \begin{bmatrix} \text{bike} & \text{type} & \text{rotation} \\ & \text{transmission device} & \text{chain} \\ & \text{force source} & \text{pedal} \\ & \vdots & \vdots \end{bmatrix}$$

The extension of relationship-element

$$Q = \begin{bmatrix} \text{Transmission} & \text{Front gear set} & \text{Chain} \\ & \text{Ratchet and slip gears} & \text{Chain} \\ & \text{Drive method} & \text{Rotation} \\ & \text{Bad effect} & \text{Come off rear gear} \\ & \text{Structure} & \cdots \\ & \text{Safety degree} & \text{Poor} \\ & \text{Disadvantages} & \text{Sully} \\ & \vdots & \vdots \end{bmatrix}$$
$$= (\text{s, A, W})$$

(4) *Through the transformation, devises the new extensible model, and found the new concept:* Once the extending tree set up, the matter-element obtained from the 1st level of extending tree should be evaluated whether it meets the demand of the new Su-field model or not. If the components cannot meet the design demands, design processes should proceed with the help of performing extension of event-element or relationship-element. Relatively, a new concept has occurred that we try to let the event "bike" to be carried out by other flexible transmission device such as belt or belt gear. The similar idea has been put into practice as the patents US2007/0228688 A1 and US2011/0241307 A1. Based on original Su-field model and new concept ideas, a new Su-field model has been constructed as shown in Fig. 1.3a. The belt transmission device is slippery under the heavy load. Association between the subjects S_2 and S_1 as " simultaneously has relatedness and distress factors", resolve their troubled association, by the standard solution 1.2.1 "useful and harmful effects exist in a system, if S_1 and S_2 is not necessary to direct contact, a new subject S_3 can be introduced to eliminate the distress factors as shown in Fig. 1.3b".

(5) Nevertheless, easy to be worn is the flaw of "flexible transmission device". We consider making the "rigid transmission device" plays the major role of bicycle devices and then, design problem becomes "How to transform the flexible device into a rigid device?" Repeat matter-element extending program. Transform the flexible device into a new general model by the

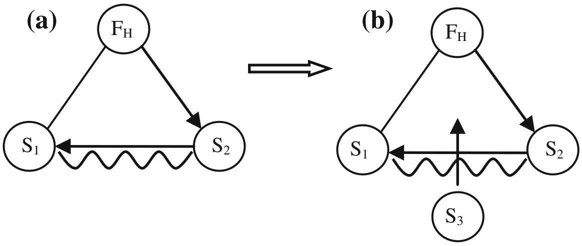

Fig. 1.3 Add new substance to eliminate the distress factors

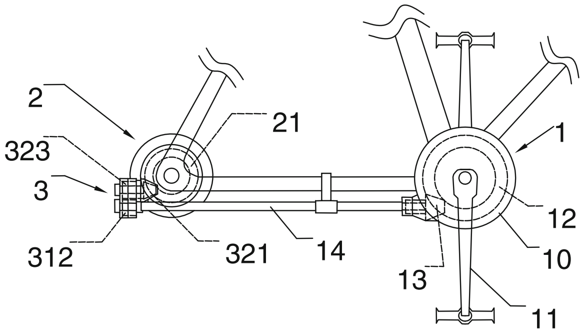

Fig. 1.4 Patent US20030209874 (Wang and Zhao 1998)

divergence tree. Therefore, restart the extending processes by taking a new matter "rigid transmission device" and a new characteristic "contact type" to set up matter-element, event-element, and relationship-element and extending tree. Many ideas will be obtained.

(6) A new device, bevel gear set, can meet the description of the new subject S_3. We may consider that use "bevel gear set" to replace "chain or belt". With reference to patent US2003/0209874 as shown in Fig. 1.4.

(7) The above chainless bicycle transmits force by mutually orthogonal meshing of the two bevel gears. Single side of bevel gear bears the force transmitted from the front gear set. Lateral forces results the free gap and leads to yaw actuator. Figure 1.5 shows the Su-field model of this design problem. The state between two substances is "insufficient effect". By reference to the 39 engineering parameters the corresponding engineering parameters can be determined. We choose 21(power) as the improving engineering parameter and 9(speed) as the avoiding worsening parameter. Thus, we obtained the innovative principles from the contradiction matrix. The innovative principles are

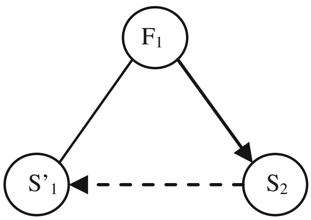

Fig. 1.5 Insufficient effect (Su-field model)

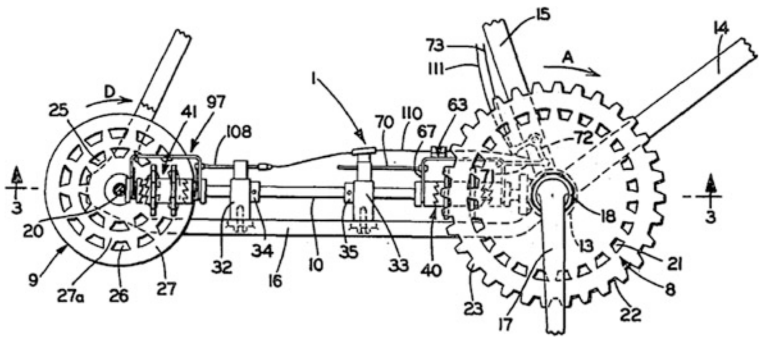

Fig. 1.6 Chainless bicycle drive mechanism. (patent US4005611) (Jeffries 1977)

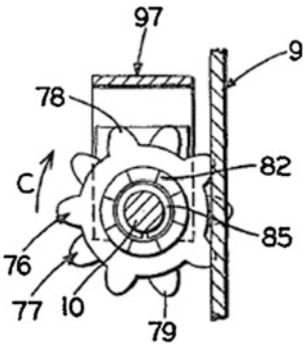

Fig. 1.7 Fragmentary sectional view bicycle rear wheel shifter and coaster mechanism. (patent US4005611) (Zhao 1998)

2(Taking out), 15(Dynamicity) and 35(Parameter changes). The method of innovative principle 15(Dynamics) indicates that dividing the object into parts so that the position can be changed between the various components. A pair of discs replaces the bevel gear sets as shown in Figs. 1.6 and 1.7. A pair of discs, each formed with a plurality of concentric series of openings, is mounted on the pedal crankshaft and rear wheel, respectively. A pair of spaced sprocket gears is rotatably mounted on each end of the drive shaft and engaged with a respective series of disc openings. A pair of operator controlled individual shift brackets is movably mounted on the drive shaft, each being operatively engageable with a respective pair of ratchet slip gears.

1.5 Conclusions

Based on the TRIZ and extension method, this study proposes an approach to innovative design problems. By possessing a symbolic system and transformation rules, the Su-Field analysis model can assist designers to diagnose and solve most design problems. The proposed innovative design procedure combines the Su-Field modeling procedure and extension method with the aides of questionnaires to improve the efficiency and extent of concept evolutions.

In this study, three important elements of Su-field model (subject S, field F and relationships) have been tried to correspond to the TRIZ contradiction matrix. Besides, we will use the extensibility of matter-element to clarify and expand Su-field model (substance or field) which is difficult to understand. The extension method can help people resolve problems separately by decomposing them, recombining the problems, and then searching for the feasible solutions, assist the Su-field model to extend and deduce concepts widely. Through the transformation, designers can conceive of other substituting matter-element models effectively and quickly to obtain various innovative design plans. We make use of extensibility of matter-element to exchange the descriptions of design problems and solutions into creative fields. The result includes,

(1) Introduce the TRIZ contradiction matrix and concept extension of matter-element into symbolic developments to derive out more creative solutions.
(2) The advantage to combine construction of symbolic system in Su-Field model and the transformation and extension of matter-elements are also assessed by preceding an innovative design case, manpower drive vehicle.
(3) Develop a procedure to transfer Su-field model to design prototype.
    The case study successfully demonstrates that the proposed design process is feasible and efficient.

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Chapter 2
From Open Source Software and Open Innovation to Open Manufacturing

Xiao-ye Zhou and M. M. Tseng

Abstract Open source software has achieved acceptable success since its emergence in early 1980s. The open concept model soon drew public attention and researchers started to explore the approach to extend the model from software to the non-software field. This paper studies several cases of open source software, open innovation and open manufacturing, to qualitatively investigate how the open model works under different scenarios: initially in a pure immaterial field of open source software, then as an immaterial part of coupled immaterial and material flows of co-design in open innovation, and finally in synchronized immaterial and material flows of open manufacturing.

Keywords Open design · Open manufacturing · Open innovation · Open source software

2.1 Introduction

Open source software has been accepted in certain business sectors as a viable system model in the increasingly rapid change of technology development. The concept has been extended to Open Innovation that goes beyond software towards creative activities like product design. How would this concept affect the production

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of physical goods? Can this model be exported and be adopted by the manufacturing process of physical products?

When considering the essential difference between software and physical goods, it is not viable to replicate the experiences of open source software and apply this directly to the physical world. There is the inevitable cost of moving materials, as well as sharing, prototyping and testing the products, which makes it more difficult to share and work together on a common project for physical goods. However, the highly developed technological and media infrastructure including 3D-based design tools, as well as the more distributed machinery, all are helping to reduce the coordination cost and make the openness of physical goods production both possible and reliable.

This paper would like to investigate the situation of applying an open model in a non-software field by studying typical cases from different industries under the following scenarios: (1) a mature open source software model in a pure immaterial field; (2) a respected and widely studied open innovation model which opens the design part (immaterial flow) of the coupled immaterial and material flows; (3) an open manufacturing model which opens and synchronizes the immaterial flow and material flow. Thus, the openness will be extended step by step, from immaterial to material fields.

2.2 Methodology

This paper will follow the qualitatively empirical research method to obtain the understanding of how an open model works. Empirical research can be defined as a research method employing means of direct observation or experiences. It acquires knowledge by qualitatively or quantitatively analyzing the empirical evidence, and from this can then attempt to answer pre-defined empirical questions. The qualitative method gathers an in-depth understanding of human behavior and the underlying reasons by working on smaller but more focused samples. It investigates why and how the decision is making by producing information on particular cases studied. Conclusions generated from qualitative study are only hypotheses or statements that need to be further verified by quantitative evidence.

In this paper, cases under three scenarios—open source software, open innovation and open manufacturing—will be studied to illustrate the way an open model works. It is hoped that this research will provide some general sense of open phenomena for other future studies in this field.

2.3 Open Source Software

Open source software (OSS) is computer software that is available in source code form for which the source code and certain other rights normally reserved for copyright holders are provided under a software license that permits users to study, change, and improve the software. According to the potential measurement matrix proposed by Crownston (Crowston et al. in press), it is convincible to state that open source software projects such as Linux, Apache Web server and Mozilla are quite successful. These three are the most well-known cases of open source software in both industrial and academic fields.

Take Apache as an example. The project started in February 1995, with the first version published in January 1996. It became the first web server software to surpass the 100 million website milestone in 2009 ("February 2009 Web Server Survey", Netcraft). The project initially had a core development group of between 8 to 25 members. This group was responsible for guiding the development of the project, voting on inclusion of core change, as well as controlling the access to CVS (concurrent version control archive) (Fielding 2002). More than 400 individuals contributed code to the project; 182 contributed to 695 PR (problem report) changes and 249 people contributed to 6092 non-PR changes. The Apache project model is described by Fig. 2.1.

Figure 2.1 also illustrates the basic project structure of general open source software. Similar structures are found in projects associated with Linux and Mozilla. Mozilla has a core group of 12 members who are the decision makers. The roadmap of the project is controlled by Mozilla.org and individuals

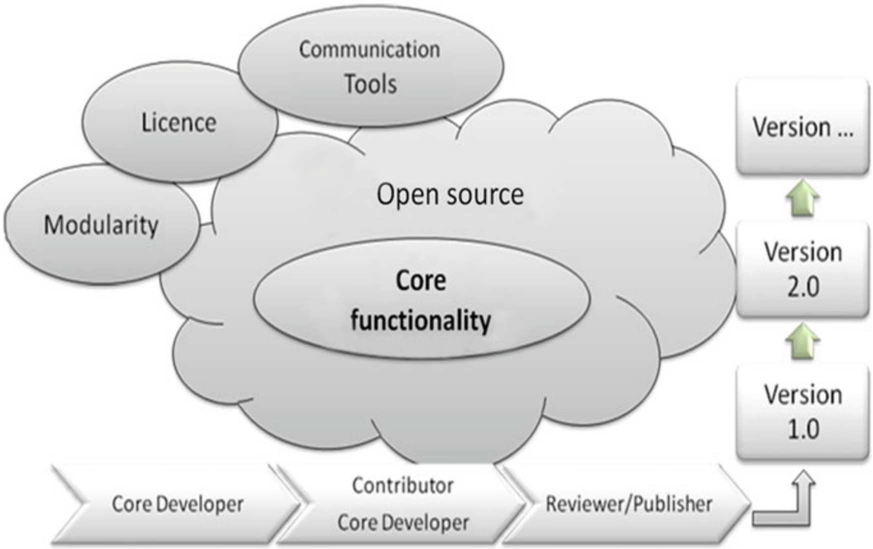

Fig. 2.1 Project structure of open source software

participating in Mozilla either contribute code to PR fixes or report PRs. Mozilla started as a commercial project, and adopted an open approach later. Linux followed an opposite approach by initially developing as an open project but then attracting a large share of firms' investment. Currently Linux promotes a very specific package, provides technical support and sells complementary proprietary products.

According to these projects, an open source software model can be described as follows: initial contributors form a "common" which is usable and accessible by others. Thus, all the users can modify it, improve it and then return it to the same common pool for further distribution. This is a cost-efficient way to fulfill heterogeneous customer needs (Franke and Von Hippel 2003a). The open model works well in this pure immaterial field because of the unique feature of the software—almost zero cost and zero time consumed to reproduce and distribute.

However, for non-software products such as physical goods, there exists the inevitable cost of moving materials, as well as sharing, prototyping and testing products during the developing process. Both capital and time barriers make the openness and co-working in a physical product project very difficult. Researchers then try to extend the open source software model to the non-software field by an "Open Innovation" approach, which focuses on the openness from the design stage.

2.4 Open Innovation

Open innovation, promoted by Henry Chesbrough, is a paradigm that assumes firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology (Chesbrough 2003). After coining the term, Henry Chesbrough then worked on the approach and tools enabling companies to build open model and formulate open strategy for open innovation (Chesbrough 2006; Chesbrough and Appleyard 2007). Analysis based on rich cases shows that the adoption of open innovation concept exists widely in different industries, not only in the "high technology" industries (Chesbrough and Crowther 2006) (Fig. 2.2).

Von Hippel modeled the sources of innovation from users, manufacturers and suppliers (Von Hippel 1988; Baldwin and von Hippel 2009), and described three typical methods of open innovation: (1) lead user method, (2) toolkit, (3) innovation contest. Tested by cases of kite surfing and rodeo kayak equipments, lead user theory is proved to be commercially attractive innovation approach (Franke and Von Hippel 2003b; Baldwin et al. 2006). Toolkits, on the other hand, work well in custom products developing fields with higher efficiency and lower cost (Von Hippel and Katz 2002). By applying these methods of Open innovation, an organization or company can then overcome its local search bias and acquire precise need information and therefore innovate more successfully and cost efficiently.

There are plenty of open innovation cases which involved customers/users in the products design and developing process using the above three methods. LEGO,

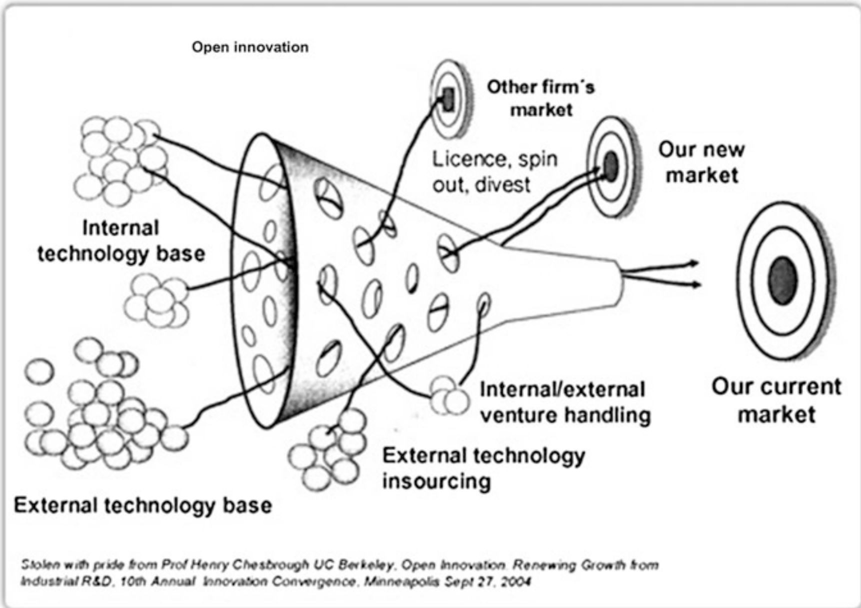

Fig. 2.2 Open innovation paradigm (Chesbrough 2003)

the famous interlocking bricks toys manufacturer, released LEGO Digital Designer (LDD), the virtual building software to support the user innovative design. Based on this design software, LEGO has also launched the Design by ME program which gives customers the opportunity to design and purchase their own LEGO model by free selection and combination of 1550 types of basic components. Threadless is a Chicago based online business which is built around a social network to run T-shirts design competitions and sell the winning designs on a website (Chafkin 2008; Orgawa and Piller 2006). Threadless provides T-shirts templates, detailed design instructions and submission toolkits to help both professional and non-professional designers to design T-shirts with colorful graphic and post their works on the website for public review, evaluation and pre-ordering. Selected winning designs with positive response and certain pre-order quantity then will be sent to production and sold on-line.

By the investigation of these open innovation cases from various industries, we can generate an open product model which also matches with the open source software style: the product is built up by combining the functional core, which is realized by material flow, and the collective creativity, which is the information flow bringing in external value to the physical product. Customers/users engage in the product developing process by contributing their intelligent ideas, which usually can be transformed as electronic edition of product designs, while the manufactures will be responsible for providing support, final production and delivery.

Plenty of cases show that open innovation promotes product variety and product customization by opening design patterns, configurable features as creativity tasks to customers. The modularized product structure raises the possibility of decoupling the information flow and material flow. Thus the design part can be separately handled by involving mass customers and users. The adoption of open innovation then offers opportunities to the public inputs by combining external ideas with material flows in a workable and manufacturable way, which highly increases the product variety and enables customization (Fig. 2.3).

So far open model is still applied only in the immaterial part or information flow of the product developing process. Is it workable for the material part? Can the developing or manufacturing processes of physical products be open? The highly developed technological and media infrastructure, 3D-based design tools, as well as the more distributed machinery, all help to minimize the cost of communication and coordination during the process. The "opened" manufacturing process seems to be possible and feasible.

2.5 Open Manufacturing

As explained by Tseng (2010), open manufacturing is a paradigm that extends the well-accepted notion of open innovation and open systems to manufacturing systems. The goal is to motivate people to participate, to create, to learn, to

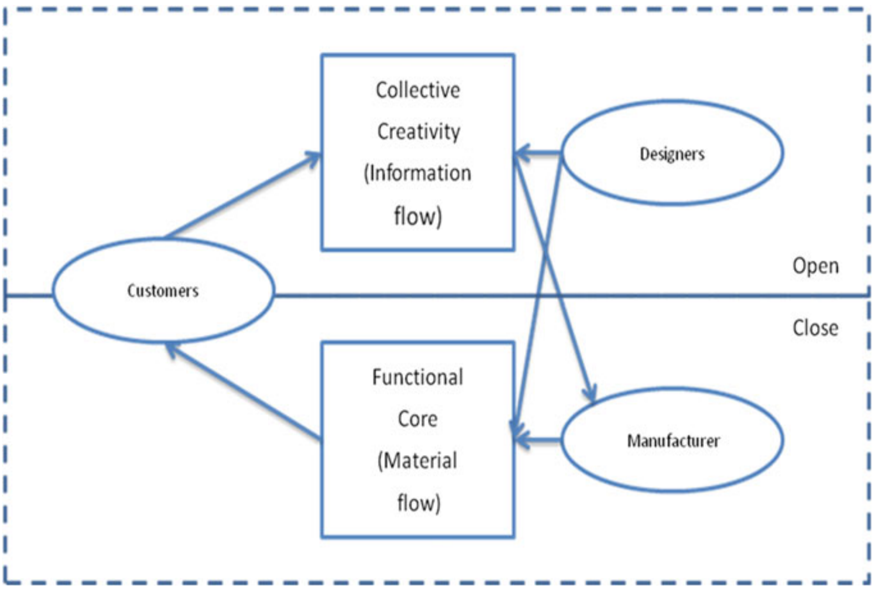

Fig. 2.3 General open innovative product model

acquire, and to recycle in a trusted environment by providing goods and services that can best fulfill human needs with capability development and satisfaction on level playing fields. Since the design, manufacturing and supply chain network of companies are getting more and more open, participants in the value-creation activities are connected and collaborate together on some “platforms” which allow them to communicate and exchange information, resources and capacity.

Consider the case of a furniture manufacturer who forms an alliance with interior designers, site workers and material suppliers to provide a one-stop-shop service to customers. The furniture manufacturer builds and supports a platform where designers and customers can get access to material and product information, as well as designing tools and skill learning materials. Thus designers and customers are encouraged to design the furniture and interior decoration plan together, to best fulfill customers’ requirements, while at the same time making maximum use of the available knowledge and resources from designers and manufacturer. The design process is supported by 3-D and collaboration design tools which save the changing cost and communication time and also make the co-design work smoothly. The design information is then sent back to manufacturer for furniture production. Based on the geographic location and capability information shared on the platform, the manufacturer will plan and work with suppliers to produce finished or semi-finished products at the most convenient facility node, which saves considerable delivery cost and time. Site workers then receive installation manual and design tips from the platform to instruct the assembly and installation work and deliver the final furniture products to customers (Fig. 2.4).

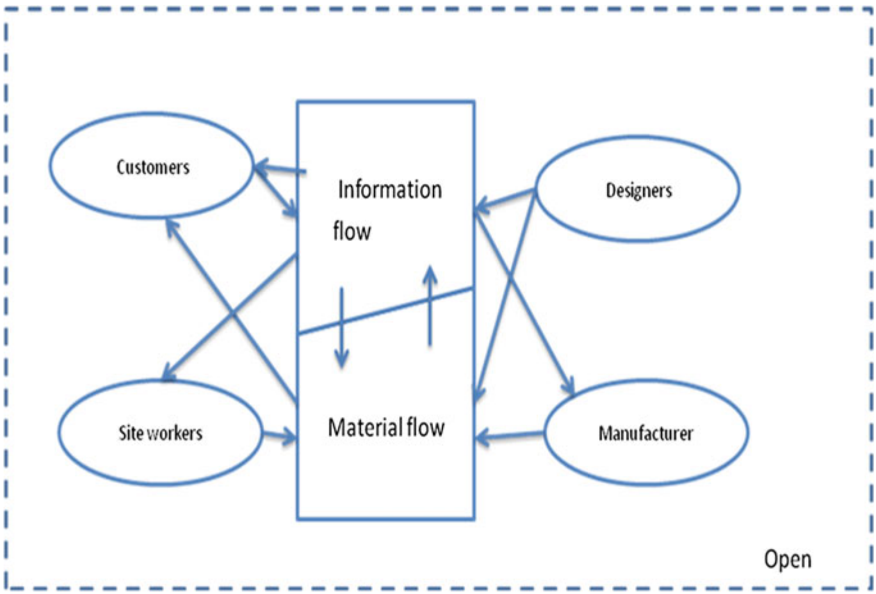

Fig. 2.4 Open manufacturing model for furniture manufacturer case

Under the open manufacturing model, the mind set of manufacturers change. Instead of keeping all the information and resources secure, they encourage and motivate customers and designers to participate in and contribute to the product developing process by providing toolkit and communication platform. All the involved parties share the information and plan/work integrally to make the developing, manufacturing and delivery process synchronized. Both information flow and material flow are open to aligned parties to take advantage of complementary capability and geographic distribution of facilities and resources, as well as the flexibility of the value-created network.

2.6 Conclusion

This paper investigates the open models of open source software, open innovation and open manufacturing by qualitatively analyzing real industrial cases. The open approach extends from the pure immaterial field of software products, to the design part of a physical product developing process under open innovation scenarios, and finally to the synchronized immaterial and material flows of an open manufacturing network. Since open manufacturing is a respectively new concept, more cases should be collected and further studied to understand its openness and mechanism. Further research questions could consider the roles of platform and each involved parties in the open model, as well as the coordination mechanism or revenue sharing contract that make the value-creation activity sustainable.

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Chapter 3
Research on Design of an Elevator in the Controlled Environment of Clean Room

Qi-bing Wang, Dong-liu Li, Li-qiang Zhu, Qing-mian Li, Zhen-bin Chen and Zhen-hao Li

Abstract A clean elevator can auto-clean the air in the cabin and transport both people and goods. It can serve in airport, operating room, food factory, electronic and semiconductor engineering, pharmacy and chemistry fields. The general information of clean elevator was introduced in this paper. The design and research of air auto-cleaning, static electricity protection, wind pressure error and ultraviolet sterilization in the cabin were discussed under the clean standard of U.S10/I.S.O.CLASS4:M2.5–U.S100000/I.S.O.CLASS8:M2.5.

Keywords Clean room · Controlled environment · Elevator · Design and research

3.1 Introduction

A clean elevator can be used in airport, operating room, food factory, electronic and semiconductor engineering, pharmacy and chemistry fields. The elevator can auto-clean the air in the cabin and transport both people and goods. It is an industrial elevator, which can serve in airport, operating room, food factory, electronic and semiconductor engineering, pharmacy and chemistry fields, functioning as air auto-cleaning, static electricity protection, wind pressure error and ultraviolet sterilization in the cabin under the clean standard of U.S10/I.S.O.CLASS4:M2.5–U.S100000/I.S.O.CLASS8:M2.5.

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The design and research of a clean elevator mainly originated from the needs of airport, operating room, food factory, electronic and semiconductor engineering, pharmacy and chemistry fields (GB/T50073-2001 2001). Presently, only several developed countries master the clean elevators and cleaning technology, which are introduced, digested and re-innovated (YBT 5198-2004 2004). Based on the elevator design and research work in the controlled environment of a clean room, the main cleaning functions design technology is described in this paper.

3.2 General Information of Clean Elevator

3.2.1 Controlled Environment in Clean Room

The clean elevator is an industrial elevator, which can serve in airport, operating room, food factory, electronic and semiconductor engineering, pharmacy and chemistry fields and is suitable for all kinds of controlled environment of clean room.

3.2.2 Application

The clean elevator is mainly used for people and goods transportation under clean-controlled environment in airport, operating room, food factory, electronic and semiconductor engineering, pharmacy and chemistry fields (GB/T25915.4-2010 2010). The clean elevator has such functions as air auto-cleaning, static electricity protection, wind pressure error and ultraviolet sterilization in the cabin, which can serve as the lifting support device under the clean standard of U.S10/I.S.O.CLASS4:M2.5–U.S100000/I.S.O.CLASS8:M2.5. At the same time, the clean elevator has the ability of high air cleaning efficiency (GB/T50472-2008 2008). The cleaning air system, fan filter unit (FFU) and ultraviolet dust removal device are adopted to realize the cleaning requirements of U.S10/I.S.O.CLASS4:M2.5–U.S100000/I.S.O.CLASS8:M2.5.

3.2.3 Main Technical Specifications

The cabin of the clean elevator was integrally formatted by punching press, using material of SS304 stainless steel. The clean elevator is equipped with <999999 m^3/h wind pressure measuring gauge (GB/T 50333-2002 2002), auto-developed SRH-JJ12 high efficient fan filter unit (FFU), operating keys of IP65 protecting class, static electricity protecting machine-roomless power machine, and a UVB mid-wave ultraviolet lighting system of 60 W with a maintaining rate of 82 %.

Table 3.1 Main technical specifications of a clean elevator

SN.	Items	Data	SN.	Items	Data
1	Capicity (kg)	630–10000	4	Cabin size (mm)	Designed for capacity
2	Velocity (m/s)	0.63–1.75	5	Power (KW)	7.5–26
3	Travel (m)	<100	6	Clean class	Class 1000–100000

The main technical specifications are listed in Table 3.1, and photo of the product is shown in Fig. 3.1.

3.3 Design and Research of Main Cleaning Functions

3.3.1 Design of Cabin Air Auto-Cleaning Function

To meet the different clean room controlled environment requirements in applicable field, a high-efficiency air auto-cleaning equipment is installed on the top of the clean elevator cabin, which has a fan filter unit (FFU) to adjust the wind speed and cleaning class automatically (GB/T 10059-2009 2009).

Fig. 3.1 Photo of the clean elevator cabin

Highly efficient filter exhausting net and admission net are fixed on the cabin sides, which can efficiently eject the return air in the cabin and filter the pollutant particulates in the air coming from the lift well (GB/T 13554-92 1992). Thus, there will be a single direction vertical air flow in the cabin, being exhausted from the sides, going upwards, and returning to the entrance of the air auto-cleaning equipment, as shown in Fig. 3.2.

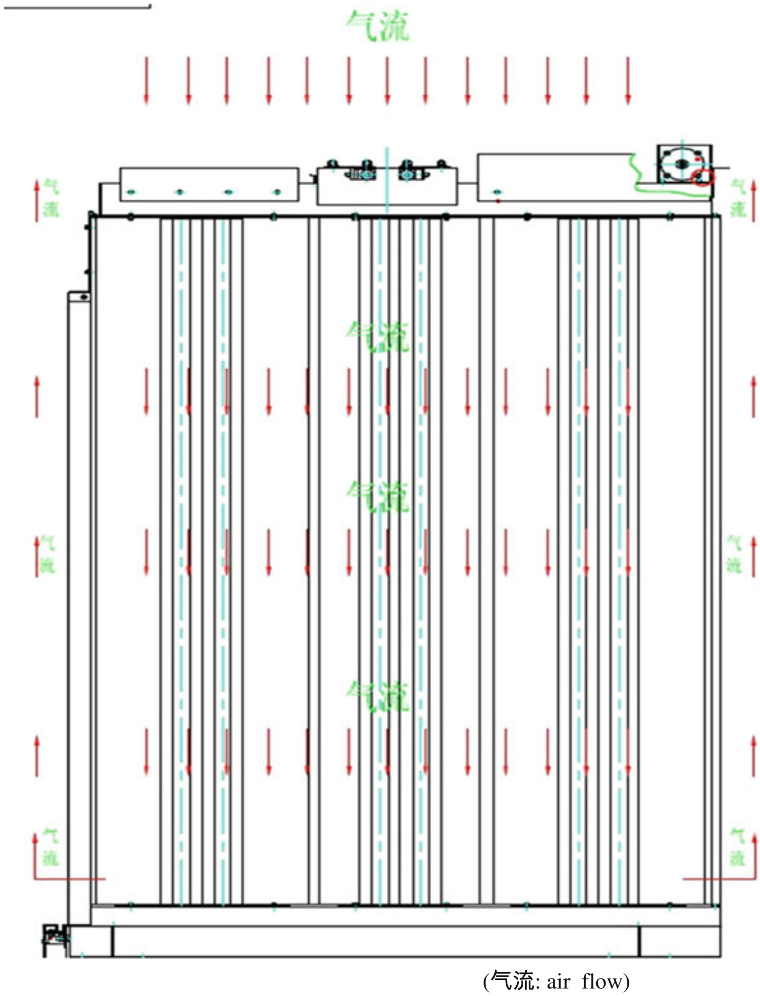

Fig. 3.2 Air flow in the cabin

3.3.2 Design of Static Electricity Protecting Function

According to the cleaning workshop design specification GB50073-2001 and US army cleaning examination standard MIL-STD-1246C-1994, there are high requirements for the running environment for clean elevator in using spots than common lifter (GB/T16293-1996 1996). For example, the wall and bottom of common lifting well can be whitewashed simply (GB/T 24478-2009 2009). But those for clean elevator should be treated with spraying static electricity protecting dope or epoxide resin static electricity protecting flooring (GB/T 24478-2009 2009). Also, the material of cabin needs high performance. At present, SS304 stainless steel and 316 medical steel are used for clean elevators (GB/T 22562-2008 2008), with the surface of static electricity protecting treatment, which can avoid the dust because of the static electricity.

3.3.3 Design of Wind Pressure Difference Function

The fan filter unit (FFU) on the top of the clean elevator often works for long time, and the high-efficiency filter in the FFU must be replaced regularly. So a pressure gauge is needed in the cabin to monitor the jam condition of the high efficient filter (GB50310-2002 2002). At the beginning, the initial resistance of the filter is 125 PA. When the pressure gauge has a reading near 250 PA, the allowable resistance of the filter is reached. And the high efficiency filter should be replaced to meet the cleaning class in the elevator cabin.

3.3.4 Design of Ultraviolet Sterilization Function

The principle of ultraviolet sterilization is described here. An ultraviolet sterilization light is a kind of low pressure mercury lamps. Its shell is made of quartz glass tube or short-wave ultraviolet glass tube (GB19258-2003 2003). Its chamber is filled with low pressure inert gases and mercury smoke. On the two ends, there are metal cold electrode or hot filament electrode. When a high electrical pressure is applied or triggered by high pressure and continually discharged by low pressure, ultraviolet will be produced with the main wave length of 253.7 nm. The ultraviolet with wave length ranging from 200 to 280 nm has a good performance of sterilization, and the ultraviolet with wave length of 253.7 nm has the most powerful sterilization ability (GB/T7588-2003 2003). The C-Band of ultraviolet has a strong function of destroying the bacteria and virus harmful to human beings. When the one-celled organism of cell or virus is irradiated by ultraviolet, the structure of vital center deoxyribonucleic acid (DNA) will be destroyed and microorganism protein cannot be produced. So the cell or virus will die immediately or lose its reproducing ability. Generally, the ultraviolet sterilization function can be realized in 1–2 s.

3.4 Conclusion

By analyzing and researching the functions of air auto-cleaning, static electricity protection, wind pressure error and ultraviolet sterilization in the clean elevator cabin, and according to the standards of GB7588-2003, GB50073-2001 and MIL-STD-1246C-1994, it is designed to ensure the security and reliability of the elevator system (LHEC rules 2009). The clean elevator is a kind of special lifting equipment, with the function of cabin air auto-cleaning.

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Chapter 4
Research on Re-Designing the Shape of Chopsticks

Zhongyang Li, Kunpeng Jiang and Ruping Cao

Abstract Being a necessary tool of eating food in Chinese people's daily life, chopsticks have the basic function of lifting food, and also have art value. By analyzing the function of chopsticks and using the "RE-DESIGN" theory proposed by Kenyahara, this essay concludes that, when re-designing the chopsticks, there are three very important aspects: first, applying the materials of environmental protection; second, designing the simple and modern chopsticks by breaking the traditional "round and square" shape; third, combining the characteristics and function of spoon and western cutlery with it.

Keywords Function · Material · Re-design · Shape · Art value

Chopsticks are the necessary tools of eating food in our daily life, which are of the practical value and art value. It has the virtue of legerity, agility and convenience, therefore it is known as the "Eastern Civilization" by the Westerns. "During the reign of the emperor Zhou the chopsticks appeared", recorded in the House of Song Wei Zi of the Records of the Grand Historian, shows that the history of using chopsticks in our country could be traced back to Shang Dynasty. The chopsticks were called "xie" during the period of pre-Qin, and then they were called "zhu" during the Qin and Han Dynasty. For the purpose of pursuit of luck in pronunciation, the ancients called the chopsticks "kuai" which was opposed to its meaning. The chopsticks, existing as a combination of culture and practical usage, embody the eastern civilization, and become the artifact which combines the research, usage, art, presents and collection in one object (http://www.yiqunren.com).

The Japanese designer Kenyahara proposed the concept "RE-DESIGN" in his book DESIGN OF DESIGN. RE-DESIGN, as its name suggests, means to design something again, which advocates going back to the start of the design, reviewing the design of our surroundings, exploring the nature of design, and enduing the

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articles of daily use with new meaning. It is a kind of creation for the designers to design something new; however, it is more challenging and creative to turn the familiar stuff in our daily life into something brand new (Kenyahara 2006). The reconsideration and re-design of the chopsticks, which are the articles of daily use shared and known by the people in our society, are worth further exploration.

Starting from the practical and cultural function of the chopsticks and taking the "RE-DESIGN" theory as the main theme, this essay will launch the discussion from such aspects as the development and application of new materials, the modeling of chopsticks, and the combination with the function of spoon and with the western cutlery.

4.1 Function of Chopsticks

4.1.1 Utilitarian Function

Not until the Qin Dynasty did people begin to use chopsticks to get food. According to the speculation of the record from Book of Rites, people used to make use of their hands to eat food. Afterwards, due to the necessity of barbecue, people began to take advantage of tools such as bamboo branches to place, turn over, and then to clip food. With the time proceeding, people in ancient time gradually learned to use auxiliary tools to clip food, and this was the earliest and most fundamental function of chopsticks (Zhang 2006). The most basic way to get food was by bare hands, and when the chopsticks were invented, they have become the extension of our hands (Xia and Shao 2011). Chopsticks became the link between hands and food when people had the necessity of fetching food. Chopsticks have guaranteed people's ability to fetch food; moreover, they have extended the function of hands so as to become the extension of them.

During the process of using chopsticks, we may meet several problems such as fetching food, comfort level of holding chopsticks, and the sound position of placing the chopsticks. Therefore, being relevant to the concept of Kenyahara's "Re-Design" theory, our point of departure should be the utilitarian function of chopsticks.

4.1.2 Cultural Function

Chinese chopsticks have various forms—the well-made chopsticks have sculptures not only on one side, but also on two sides or four sides; in addition, the chopsticks, made for the newly married couples, are two pairs and with sculptures on four sides, which make people feel romantic (Xia and Shao 2011). At the first sight, the group of Figures engraved on the alabaster ivory chopsticks only shows us the ordinary flowers and grass, and only had we appreciated the true beauty of it can we find it significant and meaningful. Cloisonné chopsticks were first made for the royal house in Ming and Qing Dynasty, which manifested the royal spirit. Cloisonné chopsticks are not totally made of wire inlays of copper; instead, the chopsticks have animal bones or ivory on the side which is used to reach food, while the copper is engraved on other parts of the chopsticks. Apart from the chopsticks with engraved ivory, there are many other kinds of chopsticks, such as Cloisonné chopsticks with engraved gemstones, mahogany chopsticks with engraved silver and emerald chopsticks with engraved gold, etc.

Chinese people have the custom of pursuing good luck by the pronunciation of some objects. The chopsticks may have the implied meaning of "May you have a lovely baby soon", "May you be happy everyday", and "Wish your kids a promising future" etc. It can express the meaning of being the acme of perfection when ten pairs of chopsticks are put together. When the chopsticks are given to the newly married couples as presents, it means "Wish your love last forever" and "May you have a lovely baby soon"; when given to the people in love, it means "Wish you be together forever"; when given to the business partners, it means "our relationship is inter-related and inter-dependent, neither is dispensable; and I won't take all the credit by my own"; when given to the people who move house, it means "Wish you make fortune, and wish you a happy moving". Due to the unique visual effects and different combination of auspicious meanings, the chopsticks are always regarded as good presents (Yang 2007).

As the carrier of culture, chopsticks have abundant cultural customs in our diet. Combining chopsticks with other ornaments or having chopsticks engraved may create unique visual images. Moreover, different combinations of chopsticks represent auspicious meanings of different types. Therefore, chopsticks are often used in our festivals, marriage customs and etiquette customs, transmitting local conditions and customs which are full of charms.

4.2 Re-Design of the Shape

4.2.1 Based on the Development and Utilization of New Materials

There exist chopsticks of different materials, such as bamboo chopsticks, wooden chopsticks, color-painted chopsticks, plastic chopsticks, bone chopsticks, silver chopsticks and stainless steel chopsticks, etc. Traditional chopsticks have the merits of being natural and gentle for they are made of wood. During the past several years, disposable chopsticks have been prevailing in the market, and because of the fact that the consumption of the disposable chopsticks is huge and they are not able to be utilized repeatedly, they have consumed vast forest resources. Meanwhile, generally there are three ways of bleaching disposable chopsticks, i.e. using sulfur dioxide, hydrogen peroxide, and calcium hypochlorite or sodium hypochlorite for bleaching. The chopsticks, bleached by the three above-mentioned methods, need washing or cooking in large amounts of water, and under most circumstances, these chopsticks won't be recycled after being used. Therefore, utilizing new materials to make chopsticks is not only beneficial to environmental protection but also it can create brand-new visual effects.

Chopsticks in Fig. 4.1 are made from recycled paper by Korean designer. Such invention is low in cost and it has nicely offset the demerits of wasting resources of the non-recyclable wooden chopsticks (Xu and Xu 2011). When using this kind of disposable chopsticks, we only need to tear the paper, and then fold it up to the three-dimensional shape according to its fold lines. This kind of chopsticks is not only portable, but also has the merits of environmental protection and hygiene, and at the same time, it reduces the waste of resources and enhances the interaction with the users.

In a Planning and Design Creativity Competition, one competitor, inspired by the methods of making fried potatoes of McDonald's, made a new kind of chopsticks by potatoes. This competitor peeled the thoroughly cooked potatoes, and stirred them with the powder of glutinous rice and flour, and after that he made it into the shape of chopsticks and put it into the microwave oven to heat it with high temperature to finalize the design, and the final step is to sterilize and seal it. Because the chopsticks

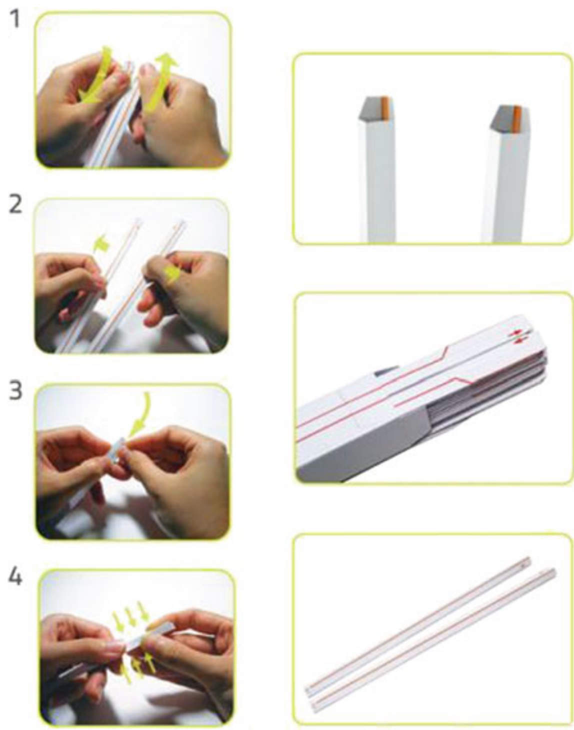

Fig. 4.1 Disposable chopsticks made from recycled paper

are made from potatoes, they could also be eaten when the meal is finished. Though this idea could not be applied in large areas, we could still consider it as a courageous and novel invention, and produce it and put it into practice in a relatively small scale such as the themed restaurants. After all, we should dare to imagine more when we want to make breakthrough on the materials of the chopsticks, and we should use more recyclable materials to economize the resources.

Therefore, while re-designing chopsticks, we should firstly de-familiarize the already-known objects such as material, usage, etc. Innovation in new material could bring about innumerable possibilities to the development and design of chopsticks so as to enhance the functionality of products. The application of new material can also provide people with fresh visual feelings and the values as well as spirits that can be felt by all human beings can be built through the process of designing so that a chord can be stricken, and this is what designers are always pursuing.

4.2.2 Appearance and Modeling

Mostly, traditional chopsticks are square on one side and round on the other, and such shape creates three advantages. Firstly, being square on one side, chopsticks can be steadily placed on the table which is very convenient for the placement and application. Next, the modeling of chopsticks makes them easier for users to hold. When we hold the square head of the chopsticks, we can pick up the food with force since the chopsticks are less likely to skip, so it is also very easy to handle the food like noodles. Furthermore, squareness offers great space for people to decorate chopsticks.

Judging from deeper cultural reasons, some scholars believe that the formation of such fundamental shape has verified easterners' preference regarding traditional shaping, namely, the shape of "coexistence of roundness and squareness". The shape of chopsticks embodies the philosophy of life of "round sky and square ground" as well as "harmony between man and nature". Therefore, the fundamental shape of chopsticks in which roundness and squareness coexist contains strong applicability and scientificity and aesthetic value. However, such succinct design can only be used widely as the carrier of the cultural concept of the society and form the cultural effect of logic when it contains the widely acknowledged concept. Also, when designers re-design chopsticks, we should consider and explore such questions (The Artificers Record 1993).

If we want to re-design the shape of chopsticks, we have to break the traditional concept of chopsticks which emphasize the "coexistence of roundness and squareness" so as to invent chopsticks which are succinct and modern. Chopsticks in Fig. 4.2 are simple, primitive and poetic. The small detail in the end of the chopsticks makes them different—a harmony combination of the shape of woodpecker and the simple but elegant trunk. Such chopsticks, which are poetic, suit the preference of modern youngsters and convert people's consumption from the level of functionality to that of psychology.

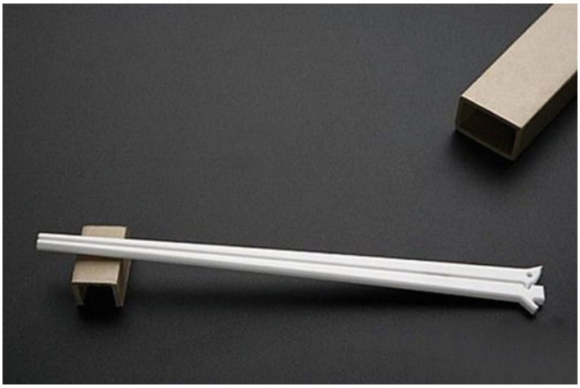

Fig. 4.2 Chopsticks whose shape is like a woodpecker

4.2.3 Combining the Function of Spoon

Traditionally, chopsticks can only be used to get food and when we have soup we have to use spoon or straw. Figure 4.3 demonstrates the chopsticks which merge the function of straw. The head of the chopsticks is placed in front of the chopsticks, while the handle of the chopsticks and the head of the chopsticks are an entirety, but the handle of the chopsticks is hollow with a straw in it, and there are covers for the heads of the chopsticks. There are covers at the far end of the handle of chopsticks which could solve the problems of having to get another spoon or straw when we want to have soup or drinks during the meal. This kind of chopsticks has unique structure, and is convenient and economic (Xiong 2005).

Figure 4.4 demonstrates chopsticks designed by French designer aissalogerot. After studying Chinese chopsticks carefully, aissalogerot discovered that chopsticks can be used as handle of spoon, moreover, chopsticks can be hollowed out to place toothpick. So when we use the chopsticks as the handle, it can fit perfectly with the spoon, therefore they can be used together. It is a thoughtful re-design of the chopsticks that the chopsticks can be used as spoon and have toothpick in it. When designing the chopsticks, the designers sufficiently use their imagination and they don't have too many concerns on personal need or economic interest, therefore their starting point focuses fully on the design. Designers are also enjoying the art of designing to the greatest extent by creating without restraint (Zhou 2009).

4.2.4 Combination with Western Cutlery

Some of the knives and forks in western cutlery, which are used to get food, have their own functions, namely, the division of work is clear. For most Chinese people, chopsticks are their major cutlery with the auxiliary of various spoons, cups, plates, bowls and dishes. The chopsticks have the function of clipping,

Fig. 4.3 The chopsticks with the function of a straw

Fig. 4.4 Chopsticks designed by French designer aissalogerot

blending and turning, etc. Fig. 4.5 shows the chopsticks-like and forks-like cutlery which is designed by Yoonsang Kim. With the premise of not altering the basic shape of strip, the designer has slightly altered the figure so as to make chopsticks

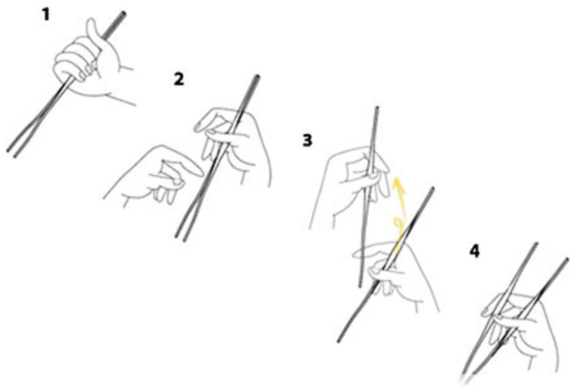

Fig. 4.5 Chopsticks with the function of forks

possess the function of fork. By changing both its shape and function, such Re-Design has endowed chopsticks with new life which made people feel fresh and new. The two connected chopsticks can give people the feeling of pulling apart the disposable chopsticks at any time. The re-design of the familiar stuffs in our surroundings is the design of design, therefore, we have to change our original thinking and explore the nature of design based on the most basic meaning that the objects want to express so that we could re-design (Shi 2009).

4.3 Summary

As one of the quintessence of Chinese culture, chopsticks have been inheriting Chinese traditional culture and carrying the specific Chinese way of thinking. As necessity that Chinese people use to get food, chopsticks have both the major function of getting food and the aesthetic value. Moreover, chopsticks play an important role in our traditional marriage customs, etiquette customs as well as obsequies for they carry unique fascination and auspicious meanings, therefore, chopsticks express the charming customs and form a unique cultural phenomenon, and they are regarded as good presents.

"Re-Design" means redesigning our daily living goods and endowing them with new lives. In the first place, we have to improve the materials used to make chopsticks by using materials which are environmental friendly. Next, we must break the traditional concept of 'coexistence of roundness and squareness' and make chopsticks succinct and modern. We should organically combine the functions of chopsticks, straw and spoon, and especially we should tightly combine the merits of western knives and forks with chopsticks so as to design novel and distinct ones.

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Chapter 5
The Caring Identification of Button Indicator of Elevator for Security

Ming-tang Wang

Abstract In this paper, we focus on the researching innovation of open-close button of elevator by questionnaire. The text of native language is found the best cognition for button indicator of open-close on the attributes of observability and relative advantage in elevator. The conclusions are: (1) Chinese characters "開(open)" and "關(close)" are the most easily observable and the highest relative advantage. So the text of native language could be the best for open-close button in elevators. (2) The complex symbols are the thick stroke with multi-element. (3) Important indicators of elevators could not only need thick black and slender arrows, but also it is non-highlighted.

Keywords Elevator · Button indicator · Caring concept · Diffusion of innovations

5.1 Introduction

An elevator (or lift in the Commonwealth excluding Canada) is a type of vertical transport equipment that efficiently moves people or goods between floors (levels, decks) of a building (Elevator 2012). Due to the evolution of human life, the rapid population increases in high-rise buildings mankind to solve the housing problem. An elevator system is a vertical transportation system responsible to transport passengers, living, working or visiting in the building, comfortably and efficiently to their destinations. In fact, elevator is very early invented the power of the

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previous movements by human, animal, steam or water pressure. At that time, manufacturing technology, coupled with appropriate safety devices, often prone to serious accidents, so are the main loading. The first reference to an elevator is in the works of the Roman architect Vitruvius, who reported that Archimedes (287 BC–212 BC) built his first elevator probably in 236 BC. (History of elevator 1990). The human use of the lifting tool as early as 2600 BC. The Egyptians build the pyramids on the use of the most primitive of the lifting system, the early lifting tools for human-powered. In 1203, a monastery in the French coast, he tried the installation of a donkey-powered crane to the end of transporting heavy loads in human history. British scientists Watt invented the steam engine, and crane device began to use steam as the driving force. William Thomson developed the elevator with hydraulic drive, and hydraulic medium is water.

In 1853, Elisha Otis needed to design a safety device for lift, which was installed on public display in the New York World Fair. The device had spring on the top of the device to achieve security (Elevator 2012). In 1857, a five-story shop installed the first Otis, and invented the safety devices to lift the passengers in New York. Since the lift has been widely accepted, it has also launched into the era of its rapid development. The initial elevator power was driven by steam engine in boiler room. Until 1880, Germany's Siemens used electricity. Thus, "electric elevator" formally appeared. In December 1889, the Otis Elevator Company of the United States created a real elevator using a DC motor as a driving force through the worm gear driven by a rope wound on the reel, suspension and lifting. In 1892, Otis began to use the button control to replace the traditional manipulation of pulling the rope (History of Otis 2012), opening the first kind for modernization for elevator.

In 1907, the first time in the six-story was installed two Otis lifts on hotel sinks of Shanghai's International Settlement in Mainland China. In Taiwan, the opening of Taipei Ju-yuan Department Store, and Tainan Lin department store, were said the flow cage (Liû-lông) during the Japanese occupation in 1932 (Taiwan old elevator 1932). The Lin department stores have also been designated as historic buildings. Their elevators are still available. Since then, the elevator affected the living and building modernization.

After 150 years, the interior of elevator has great promotion from black and white to colorful, style from straight to diversity. There is innovation in the manipulation control; the handle switch, button control, signal control, man-machine dialogue. Elevator parallel control, intelligent group control; demonstrate the double-deck elevators save shaft space, enhance the transport capacity of the advantages (see Fig. 5.1).

Chapanis (1965) noted that sometimes modifications in "words and language" in ergonomic systems could enhance human-machine interactions to a greater extent than changes in "engineering" features. One of the language-related areas that has become well-established in recent years is research on the effectiveness of warnings and other kinds of signage (Wugaker et al. 1987). Norman (1988) pointed out that interactive problems occur due to poor interface design rather than

Fig. 5.1 Structure of elevator (Structure of elevator 2012)

user inability. Effective user interface design is only possible through testing and study (Baumann and Thomas 2001). This research examines the effectiveness of four elevator service signs (Wogalter et al. 1997). There is little research for discussing vision ergonomics of elevator.

In recent, passengers most frequently encountered the elevator button, when the elevator has become necessary tools for the human in and out the building. Intermittent and out of elevators, making the switch elevators need to come up with the appropriate automatic mode after 6–10 s, which is not as long or short period of time. If the passengers in the elevator not far from the gallop over the people who want to ride the elevator reflex action will lift switch to help him smoothly into the elevator. But inside the passengers often cause from the moment mistake to push indicator display of the open-button and mistakenly closed the door, or other narrowly elevator doors, and obviously wanted to help him but get a disservice. Given mistakenly press the "open or close" button, it causes from not clear enough to explicitly key indication icon, so try to focus on researching the elevator's indicator of open-close button, to recognize cognition of passengers.

5.2 Methodology

Diffusion of innovations is a theory that seeks to explain how, why, and at what rate new ideas and technology spread through cultures. Everett Rogers popularized the theory in 1962 (Rogers 1962). Diffusion is a process by which an innovation is communicated through certain channels over time among the members of a social system. The origins of the diffusion of innovations theory are varied and span multiple disciplines.

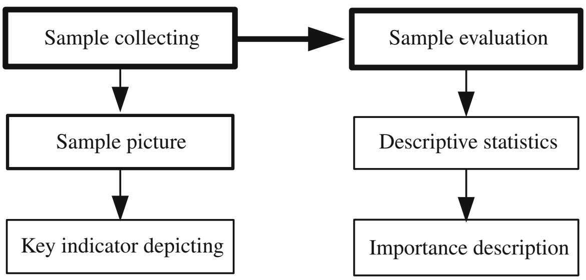
It occurs through a five-step process. This process is a type of decision-making. It occurs through a series of communication channels over a period of time among the members of a similar social system. Ryan and Gross first indicated the identification of adoption as a process in 1943 (Rogers 1962). Rogers categorizes the five steps as: awareness, interest, evaluation, trial, and adoption. An individual might reject an innovation at any time during or after the adoption process.

Cognitive attributes of the innovation are not all equally important. It is important recipient of the cognitive attributes which can be divided into (1) observability: the consequences of the innovation can let others observe; (2) Relative advantage: the old things as opposed to being replaced; the extent of the advantages of innovations; (3) complexity: the degree of difficulty of the understanding and use of an innovation; (4) compatibility: the innovations and value system of past experience. The needs of potential recipients consistent with the degree are recognized as a high relative advantage, compatibility, observability, and low complexity (Rogers 2003). Thanks to this innovation theory, the indicators of “open and close” will follow two steps as below research process in Fig. 5.2

5.2.1 *Sample Collecting*

(1) Take samples: The pictures of open-close buttons of elevators are taken from several asian countries.
(2) Key indicator depicting: In order to manage all pictures as clear shaping, each picture will be depicted into Bezier curve by using the drawing function of the software CorelDraw13.

Fig. 5.2 The process of research



5.2.2 Sample Evaluation

(1) Descriptive statistics: The description of each sample of open-close buttons is verified by descriptive statistics.
(2) Importance description: Cognitive attributes of the innovation is recognized as a high observability, relative advantage, compatibility, and low complexity.

5.3 Results

5.3.1 Sample Collecting

(1) Sample picture
There are 103 pictures of open-close button indicators which are taken from Asian countries such as Malaysia, China, Hong Kong, Taiwan, then deleted the same or similar one, and 56 pcs are left.
(2) Sample pattern depicting
In order to simplify indicators and ignore other materials, the left pictures were depicted to be white-black key indicators by software of CoreDraw (see Table 5.1), then removed the similar white-black one. 18 kinds of key indicators (see Table 5.2) were left to proceed the following research.

5.3.2 Sample Evaluation

Analysis progressed from 4 attributes: observability, relative advantage, complexity, compatibility for evaluation of Likert 7 scales. There are 113 participants to join for evaluation. They are significance of all open and close key indicators with 4 attributes from one sample T-test, therefore they are reliable to discuss.

Table 5.1 Depicting photos into diagram

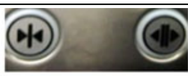
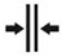
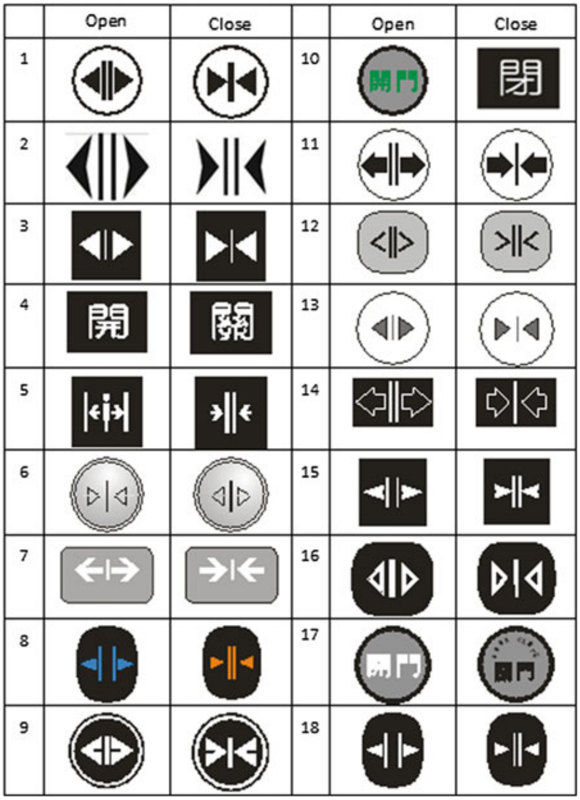
Photo			Photo		
	開	閉			
					
					

Table 5.2 Diagrams of key indicator of open-close button



According to descriptive statistics, the buttons of open and close were separately evaluated as below, and recognize which is the better or worse key indicator design. Then, the important innovation is discussed from 4 attributes evaluation.

There are 113 participants who were surveyed, included 48 males (42.5 %) and 65 females (57.5 %) in this sample.

(1) The evaluation of "open" button indicators

According to samlpes frequency observation, the reverse arrow is mainly indicated opening door for elevator.

(1.1) Observability

Although the common indicators of opening are the reverse arrow, but the Chinese character no. 4 of Table 5.2 "開(kai)" in Fig. 5.3 is the most easily observable. The second place is the thick opposite arrow. However, the Chinese text indicator is not suitable for non-Chinese countries, but it can be said that open button with the text of native language is the most easily recognized in elevator button. Perhaps we can deduce that the instructions of the universal design concept designed to make most people understand,

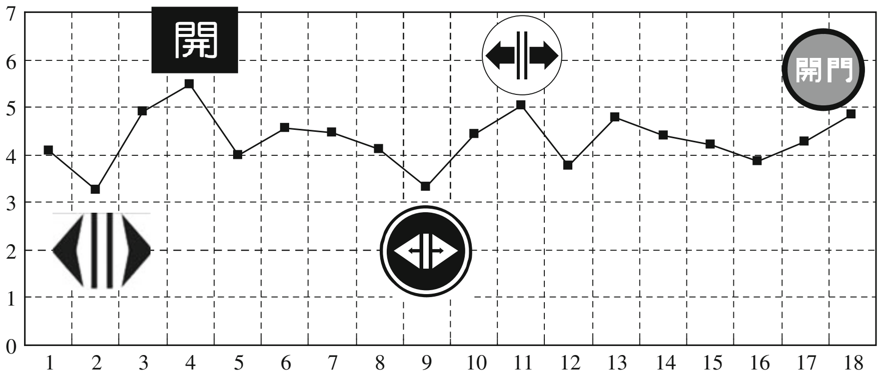


Fig. 5.3 The evaluation of observability in open button

but the national language of the keys may be the easiest observability than the other indication of the pattern-style keys for local passengers.

(1.2) Relative advantage

The old things as opposed to being replaced, the Chinese character “開 (kai)” in Fig. 5.4 is also the first place of relative advantage. The second place indicator is the same as observability researching.

(1.3) Complexity

The most complex key indicator of open button has a huamnoid between a pair of reverse arrow in Fig. 5.5, and the second complex one has high-lighted thick with horizontal line arrow key indicator. On the contraty, the simple and blunt with middle thin line arrow reverse arrow is recognized to be lower complexity.

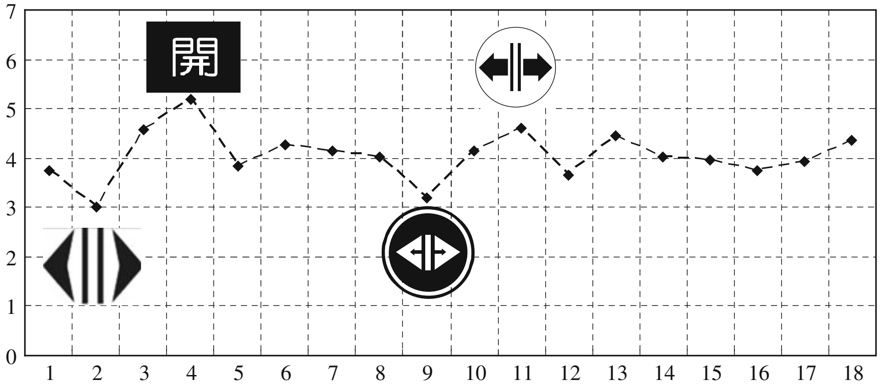


Fig. 5.4 The evaluation of relative advantage in open button

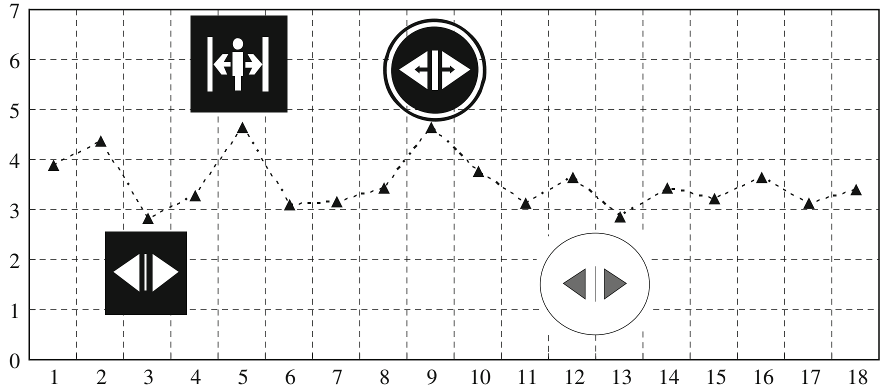


Fig. 5.5 The evaluation of complexity in open button

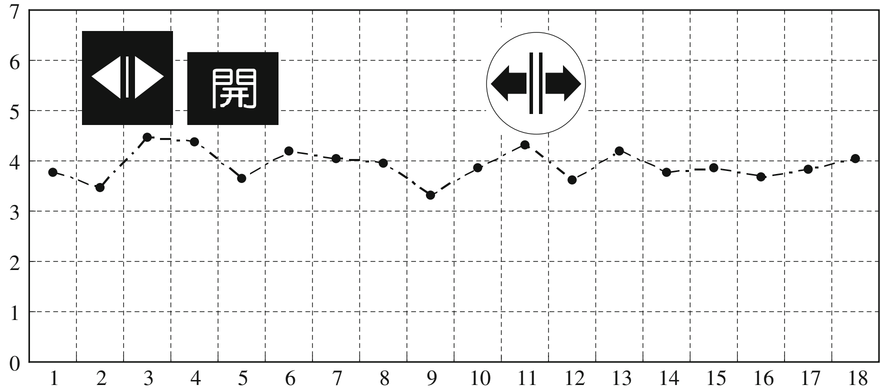


Fig. 5.6 The evaluation of compatibility in open button

(1.4) Compatibility

All key indicators are high compatibility (mean is over 3.5). It could be thought that they are selected from company and have been tested by customers. The Chinese character "開 (kai)" owns the second place in Fig. 5.6.

According to diffusion of innovation, a high relative advantage, compatibility, observability, and low complexity will be faster innovation. Then, no. 1, no. 12, and no. 16 are different situations as shown in Fig. 5.7, they could do not suit for open-button. The no. 4 and no. 11 have better relation of diffusion, the best two options for open button indicator from this research.

(2) The evaluation of "close" button indicators

(2.1) Observability

The thick and slender arrow (no. 11) is the most observable, and the Chinese character "關(guan)" in Fig. 5.8 is the secondly best observable. Although

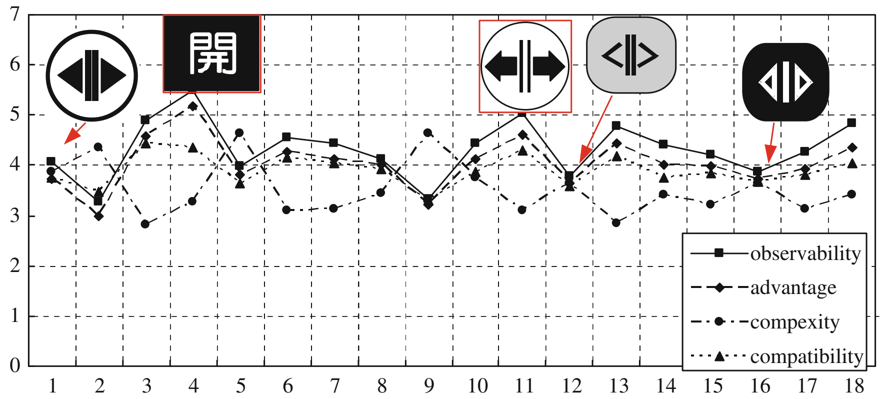


Fig. 5.7 The evaluation of 4 attributes of open button

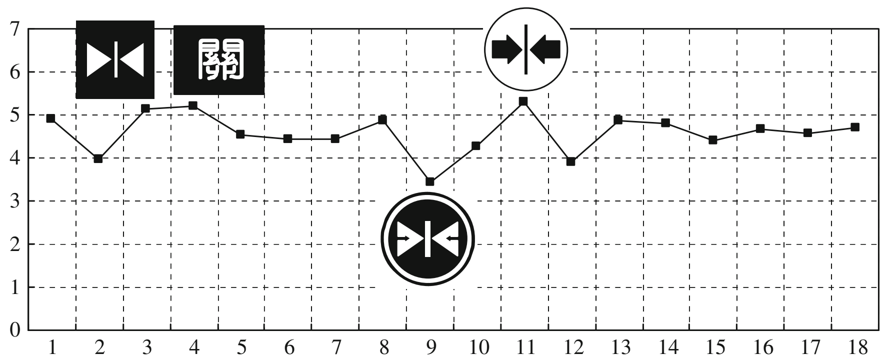


Fig. 5.8 The evaluation of observability in open button

the Chinese character is not easily observable for non-Chinese, the character is for any national riders, which is popular and easily recognizable. How to take domestic and foreign passengers into account and to take the design an appropriate indication are worth discussing issues.

(2.2) Relative advantage
In this attribute, the surveyed result is similar to observability. The thick and slender arrow (no. 11) is the highest relative advantage, an the no. 9 is the last place in Fig. 5.9.

(2.3) Complexity
The no. 9 close-button (highlighted thick with horizontal line arrow key indicator) is the same as open-button that this pair is the most complex indicator, the Chinese character "關門 (guan-men)" with "door close". It consider domestic and foreign is the second complex in Fig. 5.10. It could be said that the thick stroke, small and multi-element are the complex symbols on the indicator of elevator.

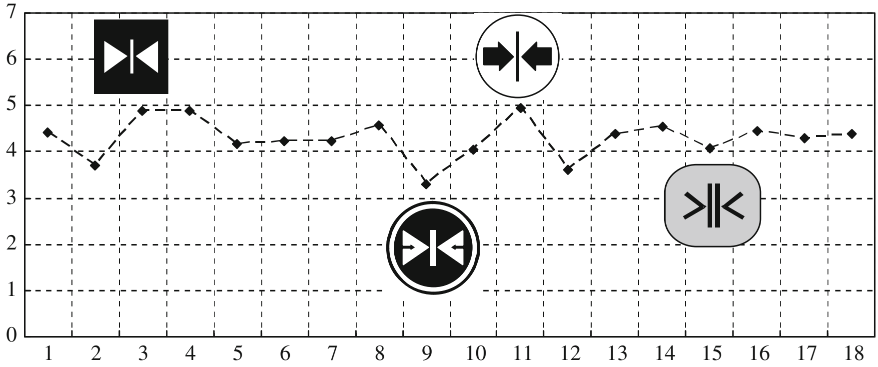


Fig. 5.9 The evaluation of relative advantage in close button

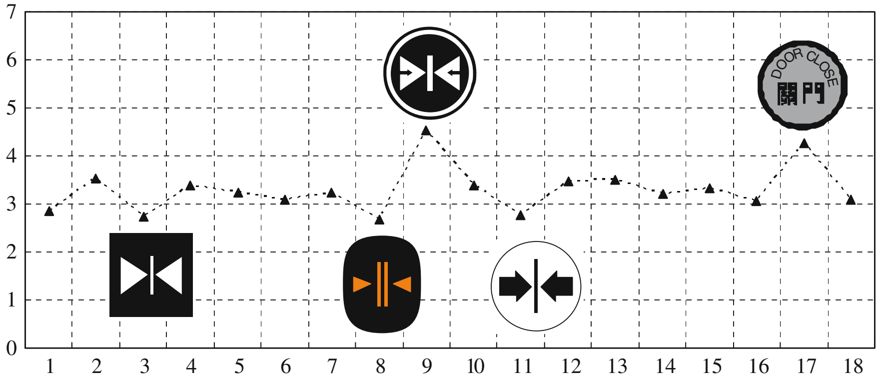


Fig. 5.10 The evaluation of complexity of close button

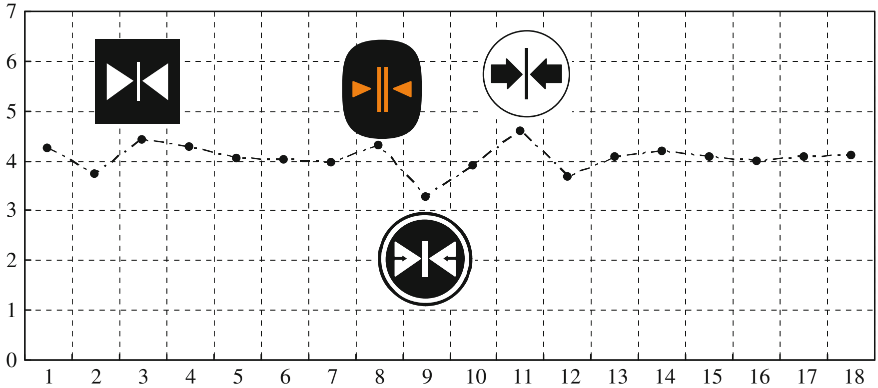


Fig. 5.11 The evaluation of compatibility in close button

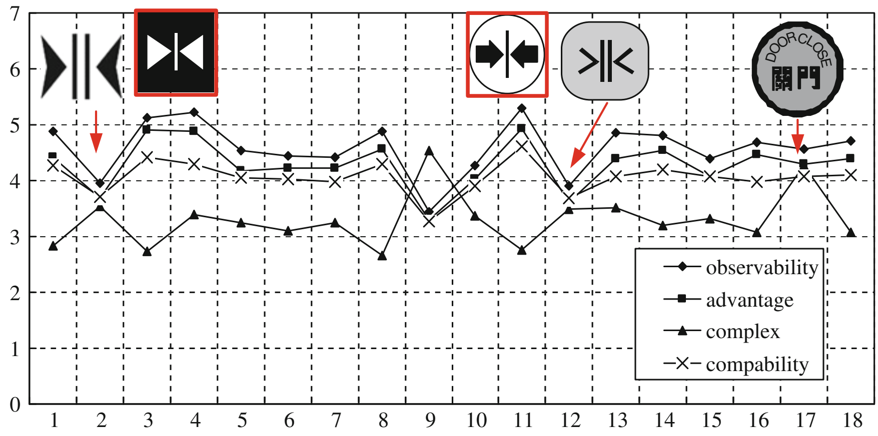


Fig. 5.12 The evaluation of compatibility in close button

(2.4) Compatibility
The close-button of no. 11 as shown in Fig. 5.11 also owns the first place as open-button in compatibility in Fig. 5.11. Thick black and slender arrow obvious arrow could be important indicators, and the same symbol concept of no.3 owns second. However, thick no. 9 arrow owns the worst compatibility, it could result from the highlight.

According to diffusion of innovation. The no. 2, no. 12, and no. 17 do not own those conditions in Fig. 5.12. They could not suit for close-button. However, the no. 4 and no. 11 have greater difference. They are better for indicators of close-button from this research.

5.4 Conclusion

From the discussion, one may conclude that the button indicator has several important recommendations to care users. (1) Chinese characters "開 (open)" and "關(close)" are the most easily observable and the highest relative advantage, so the text of native language could be the best for open-close button in elevator. (2) The complex symbols are the thick stroke with multi-element. (3) Important indicator of elevator could need thick black and slender arrow, but also it is non-highlighted.

Thus, some improvements for the scheduling aspect of this research should need advance research. It means that we should care other countries besides Taiwan for more detailed button indicators of elevator to research their cognition. Although the instructions of the universal design concept designed to make most people understand, the national language of the keys may be the easiest observability than the indication of the pattern-style keys for local passengers. How to take domestic and foreign passengers into account? Considering domestic character and universal indication design could be a solution, but it must be considered to be a simple indication.

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Chapter 6
The Design of PDC Bit for the Gas Field of Southern Songliao Basin

Peng Wu and Zhong-liang Wei

Abstract The technology of drilling in the gas field of southern Songliao basin has developed quickly in the recent years, but the potential of improving the speed is still huge. There are several kinds of PDC bits used in the high degree of hard and abrasive formation of Denlouku formation in the gas field of southern Songliao basin before the analysis, but the effect is not visible, the efficiency of drilling is very low. So for the properties of the substratum, the research based on the analysis of the rock characters, and the analysis from the aspects of the shape of the crown, the type of blade, the configuration of cutting tooth and so on, aims at designing the PDC bit for the substratum of the formation in the gas field of Southern Songliao basin. Then we reach the prospective target in the field test.

Keywords Drilling · Field test · PDC bits · Rock character

6.1 Introduction

Now PDC bit is widely used in each oil field because of the high efficiency and long service life. But when it is drilling in the hard and abrasive formation of Denlouku formation in the gas field of southern Song Liao Basin, there are some problems of PDC bits such as the drilling speed is low, the footage is less, drilling efficiency is low and so on. It has restricted the economic efficiency of drilling in the block seriously. So the design of the PDC bit which is adequate for the formation is significant.

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6.2 Analysis of the Character of Rocks

With the help of some departments, we get the debris from Qing 2-Denlouku formation of the well Yaoping10 in the gas field of southern Songliao basin. According to it, we study the hardness, plasticity, drill-ability and abrasiveness of rocks (Lo et al. 2007).

According to Table 6.1, the Denlouku formation is hard, abrasive and the grade of plasticity is low in the gas field of southern Songliao basin. The formation is hard and soft and drilling is very difficult, so we choose the G549/M423 bit (Yang et al. 2007).

6.3 The Process of Design

6.3.1 The Design of the Crown

Because of the character of the high hardness and large formation dip, the inner cone area of the crown is the shape of straight line, the shape of conic node area and outside cone area is circular arc optimized.

Firstly, this shape shown in Fig. 6.1 makes the full use of the surface of bit for the distribution of cutters; secondly, it makes the transition of gage to outside cone nice; thirdly, the manufacture is convenience (Kuang et al. 2006).

As Y axis is the axis of 12.25 inches bit; we build x–y plane (Li and Sun 2004). Among the area between radius and outside cone, the distance is not less than 6 mm. According to the character of rocks in the block, we choose the appropriate

Table 6.1 The results of analysis

Depth (m)	The grade of hardness	The grade of plasticity	Drill-ability	Abrasiveness
2192	5	2	4	6
2235	4	3	5	5
2264	6	2	4	6
2303	7	3	5	5
2362	5	3	5	5
2397	6	2	4	6
2455	7	3	5	5
2508	6	2	4	6
2570	7	3	5	5
2654	7	3	5	5
2725	7	3	5	6
2774	7	3	6	5
2861	6	3	5	5
2952	6	3	5	5
2397	6	2	4	6

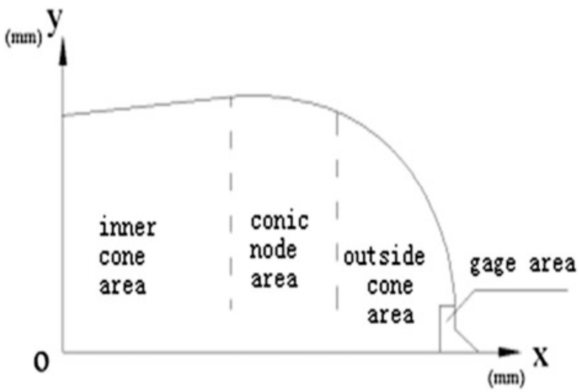

Fig. 6.1 The structure of the crown

height and angle of inner cone, and apply the soft of CAD in the design and optimization of outline of the crown. Then we can confirm the last project shown in Fig. 6.2.

The specific structure of the crown is confirmed by the function of the outline of the crown.

$$h = \int_{R_0}^{D/2} \sqrt{(R/R_0)^{2/n} - 1} dR$$

$$R \geq R_0 \tag{6.1}$$

h The height of the top of the crown;
R Nominal radius of the bit;
R_0 The radius of the top of the crown;
n The parameter of design philosophy

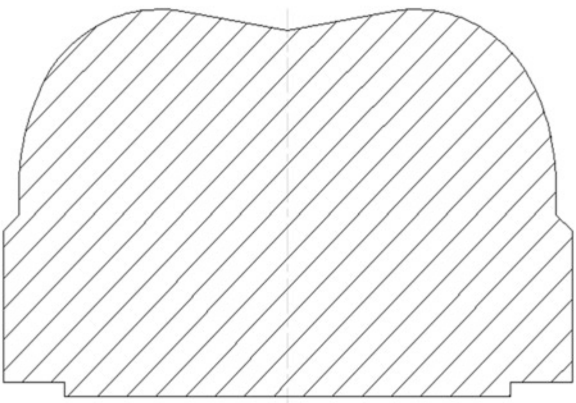

Fig. 6.2 The outline of the crown designed

6.3.2 The Design of Blades

We choose the type of blade which belongs to the auger-type. When the bit is drilling, it not only increases the contact surface of the bit and the sidewall (Sun and Zhang 2000), but also extends the contact time. And it also alleviates the whirling motion (Chen et al. 2004). So it is beneficial to steady drilling and protecting the bit (Wang et al. 2010).

6.3.3 The Density of the Tooth Arrangement

Scientific tooth arrangement should rely on the parameter of drill-ability (Ma 1996), hardness and so on which is measured, the tooth arrangement in the hard stratum is more than 45, the density of tooth arrangement is high (Dai et al. 2009). From the analysis of the experiment, the formation of the gas field of southern Songliao basin is hard and the drill-ability is bad. The density of the tooth arrangement in the hard formation is proper (Glowka 1985).

6.3.4 The Method of Tooth Distribution

Firstly, cutting teeth distributed is on the radius plane. In case of equal stock removal, the formula of tooth arrangement is as follows (Sun and Zhang 2000).

$$R_{ci+1} = \frac{R_{ci}}{2} + \frac{1}{2}\sqrt{R_{ci}^2 + \frac{8r_s r_c}{f_d}} \quad i \in (1,\ 2,\ \mathrm{K}, \mathrm{N} - 1) \quad f_d = \frac{2(N-1)r_c}{L_c} \tag{6.2}$$

R_{ci}, R_{ci+1}	The centre distance of adjacent cutters and axis;
r_s	The radius of conic node;
r_c	The radius of individual cutting teeth;
f_d	The density coefficient of cutting teeth distributed;
N	The number of the teeth distributed on the bit;
L_c	The arc length of the center of adjacent cutting teeth

According to the formula, we can confirm the radial location of every cutting tooth on the crown at last. And we can get the homogeneous projection on the bottom of the hole at last (Zou and Liang 2004).

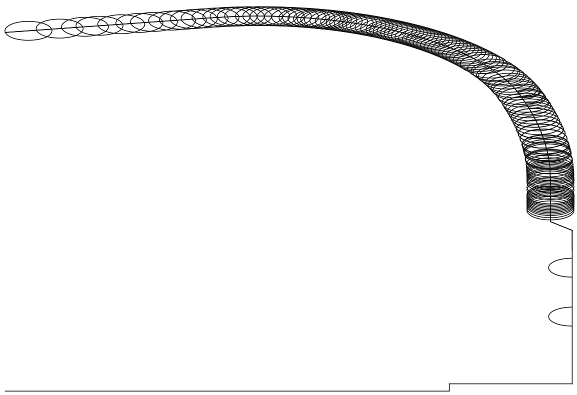

Fig. 6.3 The coverage of the bit designed in shaft bottom

Secondly, the cutting teeth is distributed in the circumferential direction on the normal plane of the axis of revolution, we can get the formula which is as follows (Li 2005).

$$\theta_{ci} = \frac{R_{ci} - R_{cl}}{R_{cN} - R_{cl}} \theta_s + \theta_m \qquad (6.3)$$
$$i \in [1, N], m \in [1, N]$$

θ_{ci}	The azimuth of the cutting teeth on the crown;
θ_s	The angle of deviation between the teeth on the gage and the central teeth;
θ_m	Any initial angle on the spiral;
R_{cl}, R_{cN}, R_{ci}	The radius of the center of teeth;
m, N	The number of spiral and cutting teeth

The general plan of the tooth arrangement and the projection on the bottom of the hole are Figs. 6.3 and 6.4.

6.3.5 The Specific Parameters of GP1322 PDC Bit

(a) The size of the bit (in): 12¼;
(b) The number of the cutting teeth: 137;
(c) The number of the teeth on the gage: 24;
(d) The diameter of the teeth (mm): ø13;
(e) The number of nozzles: The number of the replaceable is 4, the number of the fixed is 5;
(f) The type of connection: 4-1/2” API REG;

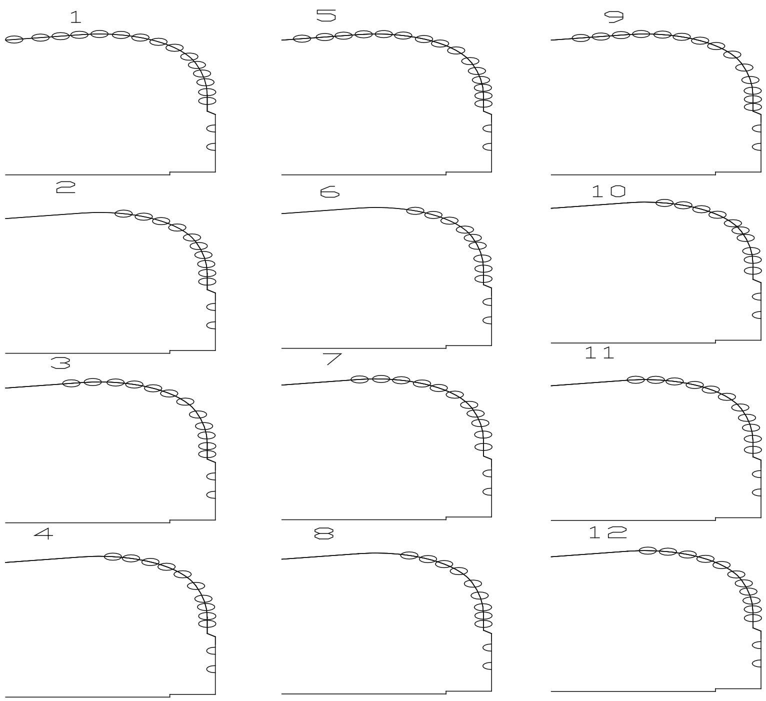

Fig. 6.4 The general plan of the distribution of teeth

(g) The ability of withstanding high temperature: 800 °C;
(h) The teeth can not come off from the bit and it is abrasive.

6.3.6 The Technical Characteristics of GP1322 PDC Bit Designed

(a) The density of the distribution of the cutting teeth is dense, and it's appropriate for hard formation (Brandon et al. 1992)
(b) The outline of the crown is shallow taper and the distribution of junk slot is favorable; it can clean and cool the bit very well
(c) The crown is constituted of cast tungsten carbide which has the high anti-corrosion properties and sinters the crown by the method of powder metallurgy (Hibbs and Flom 1978). The manufacture of the bit is simple and efficient. And it improves the property of the hydraulic parameters
(d) That the half of the teeth is out of the blade.

6.4 The Field Test

6.4.1 The Progress of the Field Test

From June 15 to 20 in 2010, testing the GP1322 PDC bit designed in the Well Yaoping10. Slacking off is occurred in the interval of 2260 m. Then the bit reamed the hole to the bottom of the hole. It adds up to 123 m, and takes 7 h.

6.4.2 Drill String Assembly

12¼″PDC bit + Screw + 9½″DC × 2+8″damper + 8″NMDC + 5+7″DC × 5+6½″DC × 14 + 5″DP.

6.4.3 Drilling Parameters

Drilling weight is 80 KN; Rotary speed is 47 r/min. Displacement is 45 L/s. Pumping pressure is 21 MPa.

The hydraulic parameters of the bit designed are as follows (Hough 1986). (Table 6.2)

6.4.4 The Result of Field Test

Drilling interval is between 2383 and 2473 m; footage is 90 m; bit time is 67.6 h; drilling speed is 1.33 m/h.

The cause of pulling out of the hole: Because of reaming down in the long interval which leads to attrition of the teeth on the area of the gage, and the bit occurred as swinging. So it can't approach the bottom of the hole directly.

Table 6.2 The hydraulic parameters of the bit designed

Type	GP1322	Nozzle (mm)	15 × 5 + 12.7 × 4
General area of nozzles (mm^2)	1389.6	Bit pressure drop (MPa)	0.74
Jet speed (m/s)	32.5	Water power of nozzle (KW)	33.3
Jet impact force (KN)	1.86	Specific hydraulic horsepower (W/mm^2)	1.36
Annular velocity (m/s)	0.71		

Table 6.3 Drilling speed and footage in the other holes

Interval (m)	Names of wells	Type of bits	Drilling speed (m/h)
3364–3674	Yaoshen6	HJT517GK	0.8
1539–2523	Lishen1	HJT517GK	1.62
Average		HJT517GK	1.07
2383–2473	Yaoping10	GP1322	1.33

6.4.5 The 12.25 Inches PDC Bit in the Same Formation in the Block

Compared with the index of the same sizes of HJT517GK bits used in the same interval of the block, the footage is improved by 1.04 times, and the drilling speed is improved by 1.24 times. Usually on the basis of the practice of the oil field, when reaming down is occurring, footage = footage of reaming down × 2+ footage of the bit in the field test, the drilling speed of reaming down is the average speed of first 50 m in the realistic drilling. The general footage of reaming down of the bit tested is 123 m which takes 7 h, so the footage is 336 m. The drilling speed of the first 50 m of the bit tested is 1.54 m/h. Compared with the index of HJT517GK bits in the same way, the footage is improved by 3.9 times, and drilling speed is improved by 1.44 times. (Table 6.3)

6.5 Conclusion

(1) The main rocks of Denlouku formation in the gas field of southern Songliao basin are the tight sandstone and mudstone according to analysis. It is hard and abrasive formation. And it is difficult for drilling
(2) During the field test of the GP1322 12.25 inches PDC bit designed in the Qin 2-Denglouku formation of the well Yaoping6, the footage adds up to 90 m, the average drilling speed is 1.33 m/h. It reaches the target of improving the speed according to the contrastive analysis.

Acknowledgments The individual GP1322 PDC bit is designed for the Denglouku formation of the gas field in southern Songliao basin in this article. The effect of improving speed is obvious. It provides a new proposal for the problems of improving the drilling speed in the block. With the development of the technology, the efficiency and quality of the design of PDC bits will make advances later. During the design of individual PDC bits, it will integrate with the new technology. And it is important for solving the problems of drilling in the specific formation and improving comprehensive economic efficiency.

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Chapter 7
The Research of Caring Design for Hand Injury

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Abstract This research combines iNPD and the role-playing method to explore the medical demand for ancillary products of hand injury patients in their daily lives. In order to understand the needs of the patients and find their problems, the design was issued by the products of caring and empathy. Forearm dysfunction, smear syrup, and dressing wounds are the most common needs. Accordingly four idea concepts are developed, and the top two popular cases are selected to complete the design proposal for self-care-related diseases peripheral products.

Keywords Caring design · Hand injury · INPD · Role-playing

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7.1 Introduction

Hand injury is often encountered in our life. The healing processes often result in inconveniences. The needs of the medical tools should be cared to solve problems. How to make the tools from the patients' perspectives in the aspects of self-life and self-treating needs a positive conception. Products designers increasingly need to consider the mental and physical needs of the users' expectations. They should not only take the features of the products into account but also the user's psychological needs. Medical peripheral products often give people the feeling of strangeness and inconsideration, or even Even self-care-related diseases peripheral products bring people the feeling as well.

In order to design the medical self-care products and understand the needs of patients in the time of injury of the forearm, except asking the patients, the designer's injuries role-playing is a more suitable method. It can change situations from short-term activities. Thus, normal people can make us know the feelings of the actual situations of the user design the products as they see fit. Thumb forceps are commonly held between the thumb and two or three fingers of one hand, with the top end resting on the first dorsal interosseous muscle at the base of the thumb and index finger. Spring tension at one end holds the grasping ends apart until pressure is applied (Thumb forceps 2012). The thumb forceps have several patterns: tissue forceps for grasping tissue (Arthur 1990; Gallo 1992), thumb forceps (Hanlon 1968; Porat 1991), sinus membrane perforation patching material carrying instrument (Razi 1993; Yamada 2012), dual closing guide for a surgical instrument (Puskas and Cube 2012) and finger mounted short spatula retractor (Poll et al. 2008). These cases were reported to emphasize the unusual nature of the objects requiring technical modifications for their removal (Ansari et al. 2000).

Therefore, to innovate product opportunities for meeting consumers' needs from the process of research, we always meet the fuzzy front end of opportunities. Cagan and Vogel (2002) proposed that a process of the integrated New Product Development (iNPD) be not just a set of methods that can be plugged into an existing company structure. It is also a way of thinking that combines three key elements: (1) A truly horizontal and interdisciplinary structure. (2) A commitment to maintain a focus on what customers and other stakeholders value. (3) A system that begins with an emphasis on qualitative methods of discovery and development and evolves toward quantitative methods of real methods of refinement and manufacture.

iNPD is a good way to transfer and combine the marketing research, engineering and design of products to explore the complex and comprehensive research. As recommended by Xin et al. (2007), they have applied this way to use motion capture as a quantitative tool to study dynamic ergonomics, physical ability both in two dimensions and in motion, to provide insights for understanding the physical limitations of users and the usability of the products. Metzler and Shea (2011) put lessons learned from a project-based approach for teaching new cognitive product development to multi-disciplinary student teams in order to deepen our understanding of the method.

Role-playing method is developed by IDEO design (Simsarian 2007). In a virtual context, the players do not have subjective experience, knowledge and context, for studying the behavior of interactive. The simulation process was acted by the play targets, and the possible bodies have mental state, feel, to experience the life of the target population to understand their needs. The use of role-playing allows design teams to explore the process in a more focused way and to share the experience from more sympathetic answer. The two most important features of the role-playing are: (1) Be in the moment: to create a design members who can focus on exploring the real environment. (2) Physicalization: the whole body to explore, produce ideas, from brainstorming to bodystorming (Randall and Randall 1954).

7.2 Methodology

In order to design self-care-related diseases peripheral products, the research will combine role playing into the process of iNPD to be a real creative integration method (Fig. 7.1).

7.2.1 The First Stage-Identifying Opportunities

In this stage, it is way to identify the situation of users and products. The user situation focuses on role-playing from 5 steps: (1) Understanding: Where to look, (2) Observation: Re-creation, (3) Visualization: Bodystorming, (4) Evaluation and Refinement: Debugging, (5) Implementation: Informative Performance.

The product situation focus on SET factors (Social change, Economic trends and Technological innovation). In order to collect the factors of all issues of SET, 8 participants will have brainstorming and then verify related issues of SET to be grouped as the product opportunity gaps (POGs).

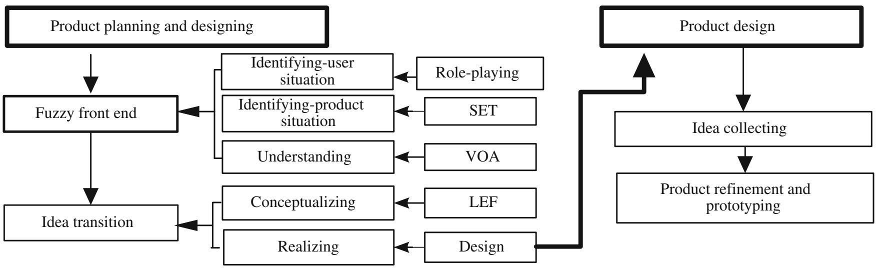

Fig. 7.1 Process of research

7.2.2 The Second Stage-Understanding Opportunities

In order to locate a better position of innovative planning as POGs, to understand the opportunities of possible products, the values opportunities analysis (VOA) will be divided into seven composite values: emotion, ergonomics, aesthetics, identity, impact, core technology and quality. Afterwards, VOA is used to make the descriptions of POGs. The five steps of process need to follow: (A) Opportunities modification: adjust and increase several values to fit for possible products. (B) Quantitative survey: It is for identifying the significant values that have a semantic survey of products from the questionnaire which is with 7 segments of Likert scale. Each average of descriptive statistics of requirement is less than 2 which is deemed as 'low'. 3–5 is deemed as 'moderate' requirements, and more than 6 is deemed as 'high'. Some of the values will be pointed to describe. (C) Find the fuzzy front end: Integrations of the high average of descriptive statistics and POGs are regarded as the direction of the product design.

7.2.3 The Third Stage-Conceptualizing Opportunities

In this stage, the pictures will be simulated the preferred orientation of significant value opportunities for target groups which will focus on the Lifestyle, Ergonomics, Figure (LEF): (A) set up the users' lifestyle to conceptualize product design direction, (B) be oriented from users, and center on caring human and earth to concentrate direction.

7.2.4 The Fourth Stage-Realizing Opportunities

In order to realize the opportunities, the concept of self-care-related diseases peripheral products are designed by steps.

7.3 Result

In this research, the iNPD method is used to work for caring hand injury to proceed product planning and designing. Its procedure is as below.

7.3.1 Identifying Opportunity

(1) Identifying user situation

(A) Understanding: In order to understand the problems of physical barriers, and then to find out points worth discussing. The use of matrix analysis is to pick out the target group, the longitudinal axis of the six target group and the horizontal axis for the category of research questions (see Table 7.1). The highest final score for the loss of forearm function as the ultimate goal groups.

(B) Observation: By the process of role-playing, disorder of the actual simulated patients, we found that patients live in the most direct, and the typical hassles. Experimenter via four one-day simulation left hand was bandaged to the dominant hand to deal with the daily way of life to discover the problems in Fig. 7.2. Self-examination and then to identify the one hand can not be engaged in the problems of integration to find the available design direction.

(C) Visualization: Words to describe the experimental results and found that the patient will feel distressed or not engaged in the following activities: (1) with one hand in the open bottles of medicine have difficulties, (2) can not eat to maintain the balance of the bowl, (3) can not wash the dishes, (4) can not squeeze cloth, towels, (5) installed a little inconvenience of detergents, (6) can not be sheer, the analog solution is to put down the toothbrush, toothpaste on the toothbrush, (7) can not tie shoelaces, (8) can not tear the sealed bag, (9) can not be vegetable, (10) can not clothesline, (11) can not effectively clean the remaining hand.

(D) Evaluation and (E) Refinement: Experimenter encountered encoding and statistics has encountered a number of times to understand what kind problems are more often encountered. According to the statistics of the number of encountered by each experimenter (see Table 7.2), it is found that the higher number of occurrences for above item. 1, 4, 9, 11, the item. 1 and 4 are the most occurrences, finally the item. 1 was selected to research.

(2) Identifying product situation

SET analysis (Social trend, Economic, Technology) is suitable for common evaluation. The brainstorming was organized to collect SET as: (1) Social trends: (A) Home emphasis on quality and home safety, are willing to accept the products of good design, not just care about practicality (B) Willing to accept the actions of self-medication (C) Accept the new product has been designed (2) Economic: Medical resources are highly developed. (3) Technology: Antimicrobial materials and antimicrobial coated technical innovation.

Table 7.1 Matrix analysis of six target groups

Target group	Research questions	Number of patients	Impact living	Dependance	Development	Difficulty	Existing product	Scores
1	Hand movements inconvenience	4	2	1	6	6	1	20
2	Loss of forearm function	4	5	4	5	4	5	**27**
3	With mobility	6	4	5	4	5	2	26
4	Loss of acting ability	5	6	6	2	1	4	24
5	Back movement disorders	2	1	3	3	3	3	15
6	Spinal deformities, rigid	2	3	3	1	2	6	17

Fig. 7.2 Role-playing to open the cans

Table 7.2 The problems of loss forearm function

Lab man problems	A	B	C	D	Total
1	◎	◎	◎	◎	4
2		◎		◎	2
3	◎		◎		2
4	◎	◎	◎		3
5		◎		◎	2
6	◎			◎	2
7		◎	◎		2
8		◎		◎	2
9	◎		◎	◎	3
10	◎	◎	◎	◎	4
11	◎		◎		2

◎ meaning is selected

7.3.2 Understanding Opportunity

Evaluation of wound healing products need to have the level of value opportunities to meet consumer demand. There are (1) Emotion, (2) Ergonomics, (3) Aesthetic, (4) Identity, (5) Impact, (6) Core tech, (7) Quality.

According to evaluation, (1) reliability and security are high evaluation in emotion, (2) safety, ease of use, and comfort are high evaluation in ergonomics, (3) visual is high evaluation in aesthetics, (4) reliability is high evaluation in core tech, (5) durability, craftsmanship, and appropriateness are high in quality Fig. 7.3.

Product opportunity gaps (POG's): Analysis of the SET and the VOA, the comprehensive results need to obtain the opportunity to care for hand injuries,

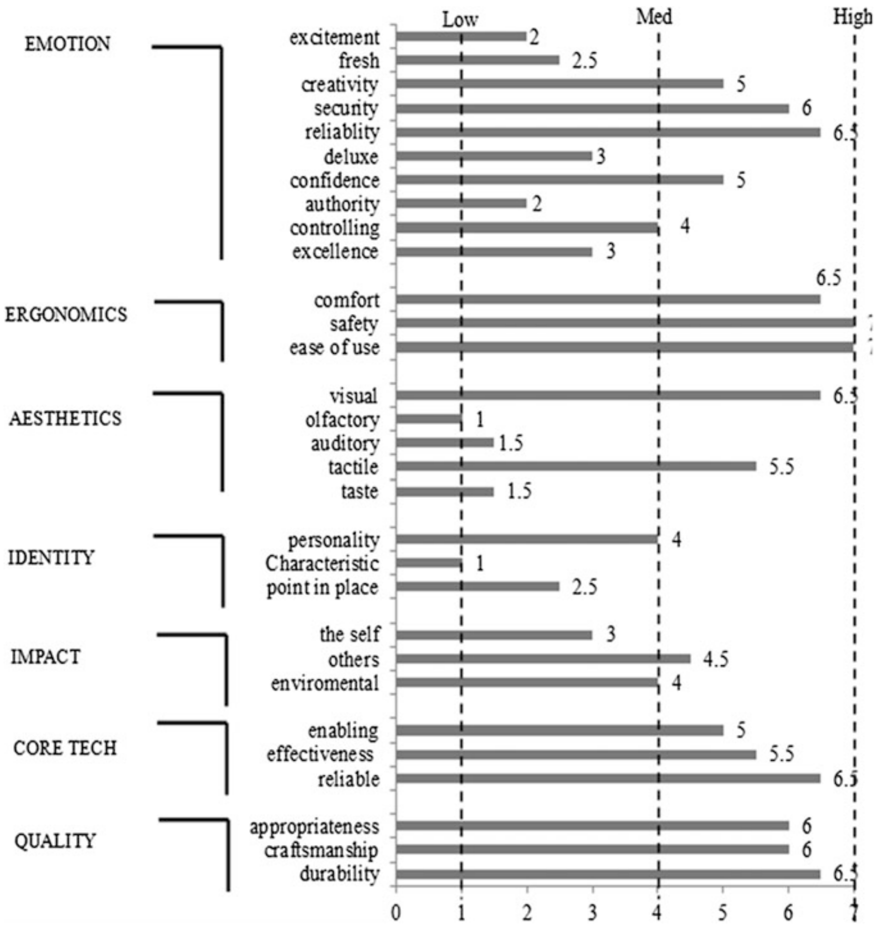

Fig. 7.3 Chart of evaluation opportunity

which are comfortable, reliable, easy to use and with the visual beauty of the most attention: (1) to have the medical needs of people feel the durability, safety, (2) to consider special populations and special situations to make our products easier and more comfortable to use, (3) to have a beautiful shape.

Design directions must be followed by lifestyle and visual themes boards. they can transfer the concepts of the design vision of the planning, the product position, and LEF matrix. They can communicate and transfer the design directions with designers to understand the conceptualization of product opportunity.

7.3.3 Conceptualizing Opportunity

(1) Concept visualization

From brainstorming and image discussion, one hand working or healing in the needs of daily living, it needs to achieve a sense of security, sense of design, reliability, ease of use and to give a tactile and visually pleasing sense in Figs. 7.4 and 7.5. The designers can follow those image boards to create their ideas, to exempt from the misunderstanding of the direction of product design.

(2) Product location

We use the “easy to use” and “sense of design” as axis, the new product should be positioned in the first quadrant of the high convenience and a high sense of design in Fig. 7.6, in order to transcend the old products and to meet the psychological needs of the target population.

(3) LEF description

The two foregoing lifestyle boards and product positioning are integrated to describe product concept with Lifestyle impact, Ergonomics, Features (LEF) (see Table 7.3).

Fig. 7.4 Visual theme board: the rich feel

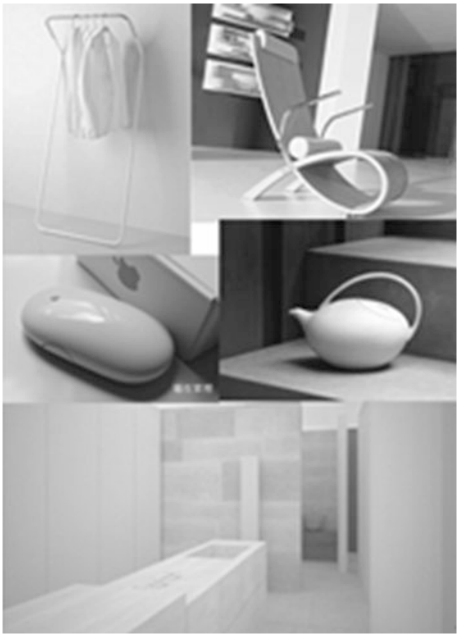

Fig. 7.5 Visual theme board: simple

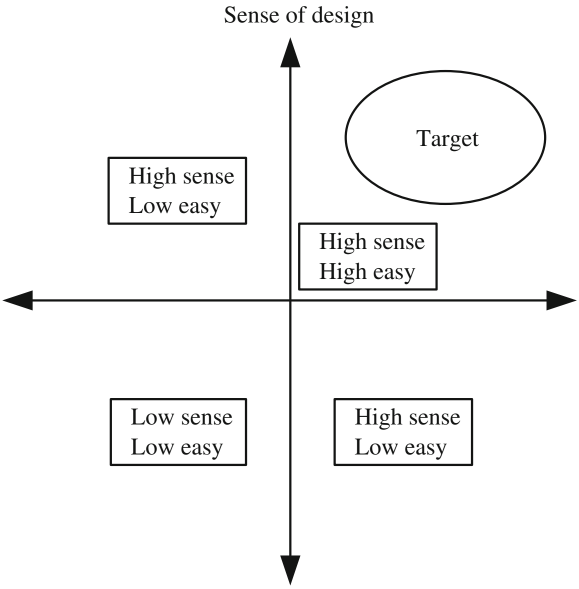

Fig. 7.6 The location of new product

Table 7.3 Product planning from LEF

LEF	Factor	Description
L	Security Reliable	Faced with a hand injury, one-handed use of security products, to continue to provide comfort in life
E	Ease to use Safety Comfort	Hand injury need to be considered more convenient than the average person to use, comfortable and safe
F	Visual	Need to pay attention to product appearance, seen not feel cold, and comfort in life

7.3.4 Realizing Opportunity

(1) Idea collecting

By the foregoing findings, the concepts development were designed a living self-care-related diseases peripheral products for hand injury.

The standable medical reverse thumb forceps have: (a) The idea of the clip can stand on the desktop, plus reverse folder so constructed as to grip the cotton, and self smear wound with one hand in Fig. 7.7. (b) One-handed use of medical tape: the patients want to tear and take glue for dressing wound by them selves is difficult. A tape unit has a plastic clip can be fixed on the edge of the medicine box, and prevents to move with the weight of the medicine box when they pull tape (Fig. 7.8). (c) One hand opens bottle of medicine: Existing security gallipot under pressure after rotation to open the caps designed ladder allows the user to hand-held single-grip bottles of medicine, against the table edge use the cap ladder gap cans to reach with one hand open tank action in Fig. 7.9. (d) Single-hand twist towel: Using suction cups to make bath brushes can be attached to the wall rotation, so the user can be with one hand wring the towel in Fig. 7.10.

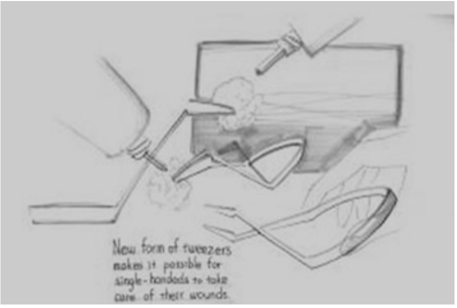

Fig. 7.7 Standing reverse medical thumb forceps

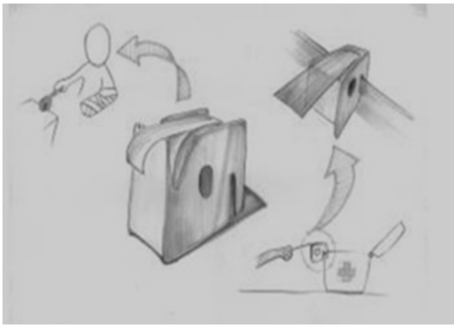

Fig. 7.8 One-handed use of medical tape

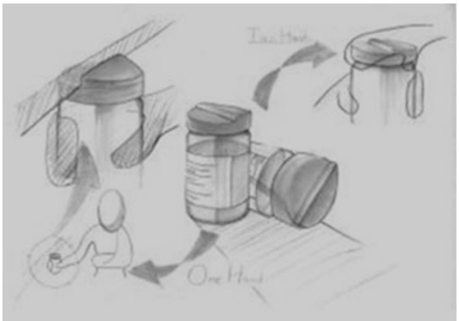

Fig. 7.9 One hand opens bottle of medicine

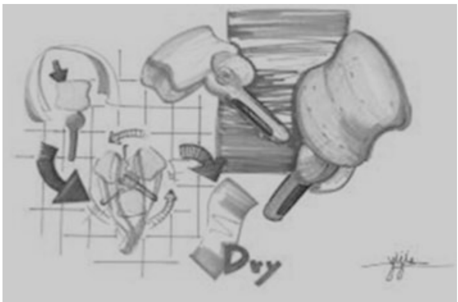

Fig. 7.10 Single-hand twist towel

(2) Product refinement and prototyping

"Normally closed" clip design concepts, and increasing the height of the Thumb forceps head, to achieve one hand can smear the drug concept in Fig. 7.11.

Using the concept of "tape measure" fixes on the medicine box in Fig. 7.12. One-handed tapes dispenser can be pulled out and broken off the tape, achieving one hand injury medical.

Fig. 7.11 Design of thumb forceps

Fig. 7.12 Design tape form tape measure

7.4 Conclusion

From this research, iNPD was made a more delicate combination with role-playing to explore the medical product needs for hand injury patients. The role-playing strengthed the patients' activities from designers role-playing, helped to understand the needs of patients and found their problems, caring and empathy will become a design issue. Hand injury has the most care. The medical tape was designed to meet with the standable medical reverse thumb forceps for self-care-related diseases peripheral products, and to be a good combination goods in family medical kit.

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Chapter 8
A Study of Human Error Prevention Mechanism Based on the Theory of Individual Information Processing

Hai Wu, Nong Zhang and Hong-bo Zhang

Abstract On the basis of individual information processing theory, the information processing of individual cognition is analyzed, namely, from the angle of information input, information processing and information output, the information processing influential factors model is established with the profound analysis of the causes of information input, processing and output distortion during the individual working process. According to the model, the countermeasures of preventing and reducing information input, processing and output distortion are proposed to decrease the human errors effectively, increase the enterprise safety production efficiency and provide theoretical basis for the formation of enterprise safety production regulations.

Keywords Accidents · Countermeasures · Information processing · Model · Prevention

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8.1 Introduction

With the development of society and the gradual improvement of enterprise hardware facilities, the reliability and security of equipment have been enhanced increasingly while the occurrence frequency of equipment-triggered accidents has been cut down continuously. However, the human cognitive efforts are also being heavily burdened because of the ever-increasing equipment operational complexity. It has become a key issue for enterprise safety production to maintain and increase the human operational reliability against ever-increasing operational complexity. In order to guarantee enterprise safety production and to decrease or eliminate the accident occurrence frequency, the human operational reliability must be reinforced. But the human errors are inevitable due to the ever-increasing operational complexity and information processing efforts (Wang and Xia 2008; Fu et al. 2009; Jin et al. 2007). And the enterprise human errors prevention should be effectively carried out. We conduct a comprehensive analysis on the cognition-caused evocative factors and occurrence mechanism of human errors during the human operating process. Furthermore, the corresponding countermeasures are proposed to eliminate the human error occurrence.

8.2 Information Processing Theory-Based Human Error Model

8.2.1 A Human-Operated Information Processing Model

At work, the machines are operated by the operator. Actually, it is a human–machine information interaction process, namely, the operator processes the information offered by the machines and the processed information is received by the machines. From the angle of cognition, this is a course of human information processing (Zhang and Cheng 2008; Ren et al. 2008), and it can be divided into three stages: information input, information processing and information output. See Fig. 8.1. (The Arrowheads indicate the information transmitting directions.)

The initial stage of human information processing is information input. At this stage, the operator receives the outside information through various sense organs and transmits the information into the central information processing system. Before being accepted by the central information processing system, the outside information can be stored temporarily in the memorizers of human sense organs for one or two seconds. During this short period, if the information can not be accepted by the central information processing system, they will disappear here. After accepting the outside information, the central information processing system, i.e. the cognitive system or decision-making system, processes the acquired

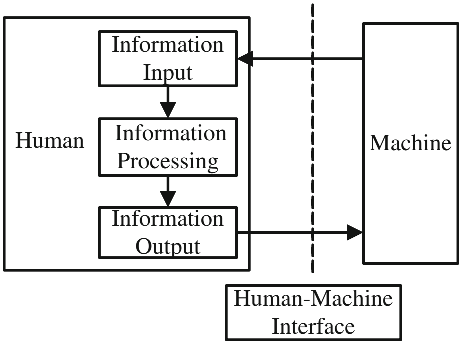

Fig. 8.1 Individual information processing model

information by editing, translating, integrating and selecting. In this course, the system continually associates with the human memory, obtains the related information from the memory and stores the useful information into the brain. Then the human reacting system will implement the orders given by the central information system and produce the output of human information processing system. The operator's cognitive behavior is performed by following this information processing model. Owing to the individual and environmental influence on every stage of this model, the information distortion is likely to occur and the human errors naturally follow (Zhang and Zhang 2003; Dai et al. 2007; Li et al. 2010; Zhu and Wang 1999).

8.2.2 Information Processing and its Influencing Factors Model

(1) *Information Input*. In order to conduct controlling activities, the operator receives all kinds of outside information through the sense organs. There are many human sense organs serving for vision, audition, touch, smell, taste, etc. Each of them has its specific functions, for instance, the sense organ of smell can estimate the chemical reaction and substance heating degree. Among these sense organs, the sense organs of vision and audition are major sense channels. The vision information almost accounts for 80 % of the total information, and the audition information is second to it. These two kinds of information have a great influence on many operational behaviors. As far as the other senses are concerned, they are less likely to be utilized by the operator for estimation and operation. Nevertheless, they can be applied as proper supplements for accurate information acquisition. This limitation may affect directly the information input, even the high-level information processing. For example, the color-encoding application range of information display is restricted by the phototonus of cone cell and rod cell, which are the sensors of the retina Jin et al. (2007).

When the sense organs are receiving external stimuli, the normal response can only be brought about within a reasonable stimulating range. This range is defined as sense limen, or absolute sense limen. In most cases, the operator receives simultaneously multiple information stimuli, not a single one. Only when one of these stimuli exceeds over the rest to a certain extent can the normal response of sensors be obtained. This kind of range is called relative sense limen. Generally, the relative sense limen is higher than the absolute sense limen. For instance, in the manufacturing workshop, the successful communication can only be realized by increasing the volume against the machine noises (Zhao and Pan 2011).

(2) *Information Processing*. Information processing refers to the course that the outside information is processed and integrated after being received and transmitted to the pallium by sense organs. It is also defined as the judgment process or decision-making process. But the capacity of information processing is limited, that is to say, the pallium can only accept diverse information completely and accurately within a certain limit. The information processing is correlative with the limit and change of processing capacity, which has a close connection with the operator's knowledge, skills and working conditions. Meanwhile, from the viewpoint of cognitive science, the information processing is single-channel, and the brain can merely process single information at a certain moment. If the operator is motivated continuously by two kinds of stimuli in a short time, it will take him more time to react to the latter stimulus than to react to a single stimulus at one time. It is proved by a great amount of scientific experiments that when a variety of information interact with each other, the following information distortion will occur during the course of information processing: ① not being processed duly; ② being processed falsely; ③ being processed lingeringly; ④ only a certain trait of information being processed; ⑤ being processed roughly; ⑥ not being processed in a required way. Then the human errors naturally appear. The researches show that the processing capacity is affected by these major factors: awakening level, motivation, training level, fatigue degree, and so forth.

(3) *Information Output*. After receiving the brain-processed information, the operator should conduct information output by performing external controlling activities, which is always being done by extremities (verbal communication is performed by the vibration of vocal cords). The upper and lower limbs have different functions: upper limbs control switch, knob, handle and operating rod; lower limbs control pedal, tread switch, and other parts. The negligence of upper and lower limbs is prone to result in the distortion of information output. It is widely accepted that the human reaction may be multichannel, and it is closely connected with human habitual behavior, for example, we can talk while walk. However, when it comes to some non-habitual behavior, the reaction will be single-channel, and this is mainly restricted by the central information processing system. It can be proved by the case that a skilled typist can fulfill touch typing whereas a beginner can hardly do this.

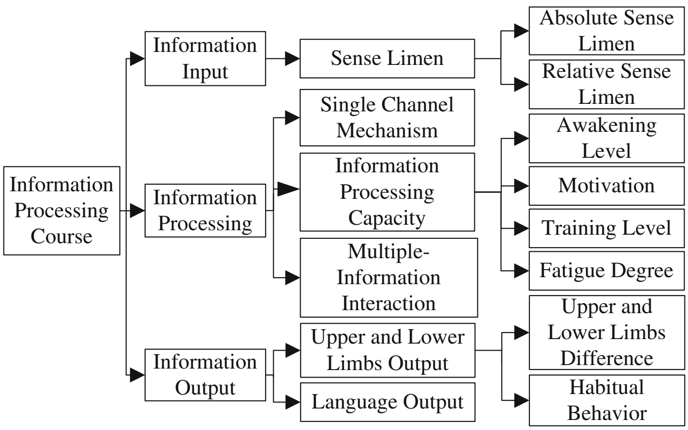

Fig. 8.2 Influential factors model of information processing course

8.2.3 Influential Factors Model of Information Processing

On the basis of previous analytical results, the influential factors model of information processing can be established (Wang 2009; Zhang et al. 2012; Zhou et al. 2008; Li et al. 2011) (Fig. 8.2).

8.3 Human Error Countermeasures of Information Processing

According to the influential factors model of information processing, the operator is always affected by influential factors at the three information processing. And each influential factor may give rise to the distortion of information processing and false processing results. Consequently, the human errors, even the human-caused accidents are generated. So we should set up corresponding prevention mechanism for the three information processing stages to eliminate the distortion and avoid human errors occurrence during the information processing.

8.3.1 Information Output Stage

Considering the perceptive range of every sense organ, we should confine all the stimuli to the individual response-generating limit. In this way, human perception errors are effectively decreased and genuine information can be obtained by the operator. When there is more than one kind of stimulus on the operating scene, it is necessarily to attach importance to the elevation of sense limen, which is caused by the interaction of various stimuli. In this case, we should try to enhance the intensity of necessary stimulus and reduce that of interferential stimulus so that the influence of interferential stimulus is minimized. Then the operator can respond effectively to necessary stimulus, acquire reliable information so as to guarantee information validity from the very beginning.

8.3.2 Information Processing Stage

Recent studies indicate that the processing capacity of brain is so limited that it should be utilized to the full.

(1) Distinguishing necessary information from unnecessary information disturbance during the interaction of diversified information. The operator can focus more on necessary information processing when his processing burden is relieved. Thus processing time is shortened, processing perfectibility is enhanced, the processing speed is improved, accordingly, precise information is achieved.
(2) Controlling the brain within a reasonable range. On one hand, the operator can not react in time on a deficient awakening level; on the other hand, the human errors may occur because of excessive pressure.
(3) Establishing corresponding motivation influential mechanism. The motivation is a powerful stimulus to efficient work. Without positive spiritual preparation and attitude towards information input and processing, the operator can not process information efficiently. The motivation influential mechanism enables the operator to understand the significance and purpose of his work and speed the information processing.
(4) Starting relevant training programs to improve the operator's skills and to save the information processing time.
(5) Framing rational operating requirements, improving the working conditions, arranging sound time-out and relieving the operator's fatigue. Hence, the operator can maintain operating consistency with a stable information processing velocity during the whole working day.

8.3.3 Information Output Stage

In the course of information transmission, the most important carriers are the upper and lower limbs and language organs. Owing to the physiological difference, the selection of carrier requires careful consideration.

(1) From the viewpoint of physiology, it is obvious that the flexibility of upper limbs is superior to that of lower limbs. Consequently, in the course of information output, complicated information is assigned to upper limbs while simple information is committed to lower limbs. Moreover, we should keep

the information burden balance of upper and lower limbs so as to avoid information output inaccuracy and to reduce human errors.

(2) Eliminating the influence of habitual behavior. Habitual behavior is a kind of practice, which is formed in the long history of work and life. In order to eliminate the information output errors caused by habitual behavior, it is necessarily to remove the difference between tool design and the habitual behavior. Therefore, we should take the human factors into serious consideration in the aspect of factory and tool design to make the tools and controlling facilities accord with our operating habits. In the meantime, the operator should cultivate safe operating habits in the operating process.

8.4 Conclusion

It can be seen that the accurate information transmission should be guaranteed so as to prevent the occurrence of human errors. On the basis of the above studies, we acquire the following findings.

Firstly, the information processing can be divided into three stages. To cut down the occurrence of human errors at each stage, it is necessary to have a deep insight into the characteristics of each stage.

Secondly, at the information input stage, we should limit the necessary information input stimulus within a reasonable intensity range and decrease the influence of interferential information stimulus. Thus the information distortion and human errors at this stage can be effectively avoided.

Thirdly, at the information processing stage, the information distortion and human errors caused by information processing delay can be avoided by relieving the information processing burden of the brain, enhancing the processing efficiency, ensuring appropriate information stimulus intervals, enlightening the operator on the work motivation, training the operator for skillful operation and establishing rational rest system.

Finally, at the information output stage, proper work assignments of the upper and lower limbs, along with scientific design of man-friendly tools can effectively avoid information distortion and human errors.

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Chapter 9
Man–Machine–Environment System Evaluation of Building Operations in Our Country

Ya-wen Dong, Jin-yong Dong and Xiao-hui Zhao

Abstract Environments of the building operations are bad and vocational damnifications are severe in our country. This paper probes into the actuality of the man–machine–environment system from the three aspects of human, machine and environment for the building operations in our country. And designs the evaluation index system, evaluates the validity of the man–machine–environment system. The evaluation result shows that the whole validity of the man–machine–environment system is common. And the urgent problems are manifested by the laborers' technology level of building operation, the validity of the small manual or power machines and tools, climate and dust conditions. This paper also suggests that construction enterprises should cooperate with talents cultivation institutions and take part in the development and production progress of machines and tools, etc.

Keywords Building operations · Evaluation · Ergonomics · Improvement · Man–machine–environment system

9.1 Introduction

Building industry is one of pillar industries for economic development in our country. It also is a base for the correlated industry to develop, and has been ranked as a key industry to develop. It will soon become the pillar industry which drives our economic growth and structure upgrading. Along with the economic

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development of our country, building industry has also acquired a rapid growth currently and its pillar position has been prominent (Wu 2008). However, all the time the casualties are remaining high and serious and exceptionally serious accidents have been happening continually (Albers et al. 2005; Zeng et al. 2008). This actuality has brought heavy losses for the national economy. So building industry has become the first industry whose accident rate is maximal except for mining industry (Ding et al. 2006). At the same time, the harm of occupational diseases is fatal in building industry. Laborers have been working in bad conditions at construction site day by day; they contact and suck all kinds of hazardous and noxious substances. Their body health is be damaged badly (Wua et al. 2010; Lai et al. 2010; Saurin et al. 2010; Martínez Aires et al. 2010; Gambatese et al. 2008). As well as construction laborers perform many physically demanding tasks including cleaning and preparing construction sites, digging trenches, operating power tools, tending machines, loading and unloading building materials, and mixing and placing concrete (Zeng et al. 2008; Li and Song 2009). Thereby construction laborers are at significant risk of work related musculoskeletal injury. These above activities expose laborers to ergonomic risk factors such as awkward postures, frequent heavy lifting, repetitive motions, hand, arm and whole body vibrations (Silverstein et al. 2002; Hess et al. 2004). Trace it to its cause, our industries lack the effective application of Ergonomics like the other developing countries, and pay little attention to occupational health and safety, so bring inefficiencies and more hardships for construction laborers.

For this reason, the paper proceeds from the research object of Ergonomics, namely the man–machine–environment system, analyzes the validity of man–machine–environment system for building operations, designs the system evaluation model, and suggests the corrective measures in order to improve the work efficiency, health, safety and work satisfaction of laborers.

9.2 Man–Machine–Environment System Analysis of Building Operations in Our Country

9.2.1 Actuality Analysis of Construction Laborers

Along with the continuous growth of national economy, a good many large, medium and small mechanical equipments and advanced productivity factors are widely applied at construction sites. However, due to the complexity, diversification, polytrope of working routine at construction sites, man as a factor will still play a dominant role for a long time. At present, peasant workers have become the main force of building operations in our country. Peasant workers nearly account for 90% above of building army. Technical threshold of personal services in building industry is very low; therefore most of construction laborers' cultural level is lower. Their skills are learned from their masters in doings. In the learning process, there is only craft teaching and the interrelated foundational knowledge is extreme insufficient.

Based the situation of construction laborers above, because of their cultural level, living environment, economic position and the other factors, peasant workers mainly pursue the efficiency of construction in the progress of construction. They are off their guard about safety of construction. Even a good many construction laborers have no consciousness of body health, occupational safety, pleasant surroundings and a good state of mind. These factors are basic reasons to worsen working atmospheres.

9.2.2 Actuality Analysis of Construction Machines

The machines widely used in construction industry may be divided into three large classes. The first kind are large and medium-sized mechanical equipments, such as hoisting machinery, namely tower crane and auto crane, gantry, rooter, pile driver, concrete mixer, road roller, etc. The second kind are all kinds of the small manual or power machines and tools, such as portable cutter, angle grinder, woodworking machinery, steel fixer machinery, bricklayer, etc. The third kind is safe guarding appliances, such as safety net, safety belt, safety helmet, safety rope, etc.

Because construction enterprises have implemented program contract system in recent years, therefore in order to reduce cost and fight for more economic benefit, many construction enterprises firstly consider whether machinery equipments and tools can satisfy construction requirements when they purchase the equipments and tools. These enterprises ignore the amenity of design, namely convenience, laborsaving feature, safety and health indemnity of operation crews. So the automation degree and humanization level of these construction equipments, safe guarding appliances and manual tools used at many construction sites are low. The current situation of machinery equipments easily causes damage to laborers' body health, even causes casualty accidents.

9.2.3 Actuality Analysis of Construction Environments

Operating environment directly impact the efficiency of man–machine system, body and mind of laborers. And it involves a lot of contents. The affinitive conditions of building operations include climate, dust, high altitude and noise.

9.2.3.1 Climate Conditions Analysis of Building Operations

Hot or low temperature environment influences work efficiency. Human will have a big discomfort and even pass out if they are in hot or low temperature environment for a long time. And the incidence of productivity accidents is very high in hot or low temperature environment. At the same time, many machinery equipments' electric engines easily are burn down if the temperature is too high. Reversely machinery equipments will not be started normally if the temperature is too low.

Meanwhile, rainy season construction is a big problem in construction sites. In some regions there is a certain seasonal rainy season. Big earthworks easily collapse in rainy season. The excavating in rainy season not only is dangerous, but also is inefficient. It likely brings rework. In seasonal rainy season, external wall plastering, painting and coating can not be carried out, and these operations easily shed as a result of wet.

9.2.3.2 Dust Conditions Analysis of Building Operations

In the process of building, excavating earthworks, piling up, clearing up, backfilling, leveling of the land and building materials' loading and unloading, transporting and the other doings can all produce dust. The density of dust is very high and the dust environment can result in serious dust pollution in building. Long-term working in the dust environment, laborers will have respiratory diseases, chronic bronchitis and the other diseases, even cancer.

The consciousness of environmental protection and self health care for most laborers is poor. They have not realized dust pollution's harm to human bodies and environments. And they seldom wear properly labor protection articles. Construction enterprises can't monitor the density of dust periodically in order to adopt measures. In the process of building, construction enterprises consider mainly the effect of construction procedures and operation methods for efficiency of construction. They have not improved and pointedly managed these procedures generating dust. The sources of dust have not been controlled effectively.

9.2.3.3 Conditions Analysis of Work High Above the Ground in Building Operations

High falling is the main reason of industrial accidents in building operations. High falling accidents have attained the range from 40,000 to 75,000 and 80 % of accidents are fatal accidents (Wang 2008). Therefore, the management of work high above the ground is the most important thing of security management in building operations. Plasterers, steel fixers, form fixers and the other works are all involving work high above the ground. At present many laborers don't wear seat belts and there is no safety net set in construction sites. The simple falseworks are only set up. Once slippage happens, the safety of laborers can't be guaranteed at all.

9.2.3.4 Noise Conditions Analysis in Building Operations

Noise does great harm to human bodies. The greater noise can cause fatigues, dizziness, sleep disorders, distraction, and memory to go down and so on. Noise can make your heart go faster, generate arrhythmia, even change your blood pressure.

The phases from earth and stone cubic, piling, structure construction to fitment are relatively long in construction time. And these phases apply a lot of construction equipments, and the noise pollution is more serious. In the process of building, all kinds radiations of sound sources mix mutually to make noise level higher and radiation scope bigger.

9.3 Man–Machine–Environment System Evaluation of Building Operations in Our Country

After analyzing the relating factors of man–machine–environment system of building operations in our country, the paper probes the system evaluation (Liu and Dong 2006).

9.3.1 The Evaluation Index System Identification of Man–Machine–Environment System

According to the three factors' contents of man–machine–environment system in Ergonomics, the paper identifies the evaluation index system. Initial three first level index are identified, namely man's factors, machine's factors and environment's factors. The detailed evaluation factors are shown as in Fig. 9.1.

9.3.2 The Evaluation Index System Determination of Man–Machine–Environment System

9.3.2.1 The Correlation Degree Investigation of the Initiative Evaluation Index System

The correlation degree of each index and the validity of man–machine–environment system is divided into six levels, namely very close, close, relatively close, common, weak correlation and no correlation. The site investigation against a China's leading internationalized construction service company is made. 30 questionnaires are offered and recovered 24. Rejecting the unqualified

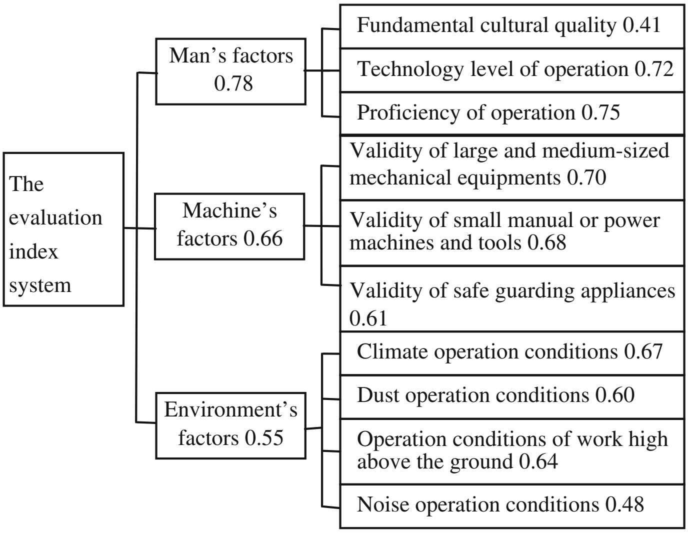

Fig. 9.1 Initiative evaluation index system of man–machine–environment system in building operations

questionnaires, the remaining qualified are 20. The importance investigation results of the evaluation index system are obtained, as shown in matrixes R and R_1–R_3.

$$R = \begin{bmatrix} r_{11} & \cdots & r_{16} \\ r_{21} & \cdots & r_{26} \\ r_{31} & \cdots & r_{36} \end{bmatrix} = \begin{bmatrix} 0.35 & 0.25 & 0.35 & 0.05 & 0.00 & 0.00 \\ 0.15 & 0.35 & 0.30 & 0.10 & 0.05 & 0.05 \\ 0.10 & 0.15 & 0.35 & 0.25 & 0.10 & 0.05 \end{bmatrix}$$

$$R_1 = \begin{bmatrix} r_{111} & \cdots & r_{116} \\ r_{121} & \cdots & r_{126} \\ r_{131} & \cdots & r_{136} \end{bmatrix} = \begin{bmatrix} 0.05 & 0.05 & 0.15 & 0.45 & 0.25 & 0.05 \\ 0.20 & 0.35 & 0.35 & 0.05 & 0.05 & 0.00 \\ 0.35 & 0.30 & 0.15 & 0.15 & 0.05 & 0.00 \end{bmatrix}$$

Similarly, we can get R_2 and R_3.

In the foregoing matrixes, $r_{ijk} = d_{ijk}/d_n$, and d_{ijk} is the number of people selecting evaluation k for attribute index j under subgoal i. In the matrix R, $j = 0$ and d_n is the total number of people participating the evaluation. In the example $d_n = 20$.

9.3.2.2 The Correlation Degree Determination of the Initiative Evaluation Index System

By determining the validity evaluation index set F and the evaluation set E, the correlation degree matrices N, N_1, N_2 and N_3 are obtained, as shown in Fig. 9.1.

9.3.2.3 Determining the Valid Evaluation Index System

Because the three primary indexes are three big ways of the system, and their correlation degrees are greater than 0.5, so the three primary indexes aren't deleted.

For attribute indexes, the indexes being smaller or equal to 0.5 will be deleted, and the others are valid. The valid evaluation index systems are acquired, as shown in Table 9.1. In Table 9.1, weighing w_{ij} is computed by the correlation degree normalization of all kinds of indexes.

9.3.3 The Evaluation of Man–Machine–Environment System

9.3.3.1 Determining the Evaluation Language Set

By system engineering principles, the quality level of man–machine–environment system is divided into five grades, namely very good, good, relatively good, common and bad.

9.3.3.2 Determining the Evaluation Calibration

By the evaluation language set, the evaluation calibration is determined.

$$E^{'} = \left(e_1^{'} \quad e_2^{'} \quad e_3^{'} \quad e_4^{'} \quad e_5^{'}\right) = (1.0 \quad 0.75 \quad 0.5 \quad 0.25 \quad 0)$$

9.3.3.3 Computing the Relative Membership Grade of Each Index

(a) Evaluating the validity of man–machine–environment system
Construction managers, construction technical managers and builders of this construction company being evaluation subjects, 20 valid questionnaires are obtained. The validity evaluation data of man–machine–environment system is shown as Table 9.1.

(b) Handling the result of validity evaluation

(1) Determining factor evaluation matrixes R'_i
By the data in Table 9.1, R'_1, R'_2 and R'_3 can be obtained.

$$R_1^{'} = \begin{bmatrix} r_{111}^{'} & \cdots & r_{115}^{'} \\ r_{121}^{'} & \cdots & r_{125}^{'} \end{bmatrix} = \begin{bmatrix} 0.15 & 0.05 & 0.20 & 0.45 & 0.15 \\ 0.20 & 0.30 & 0.35 & 0.10 & 0.05 \end{bmatrix}$$

Table 9.1 Valid evaluation of man–machine–environment system in building operations

Primary index	Weighing w_i	Secondary index	Weighing w_{ij}	Very good	Good	Relatively good	Common	Bad
Man's factors	0.392	Technical level of operation	0.490	3	1	4	9	3
		Proficiency of operation	0.517	4	6	7	2	1
		Validity of large and medium sized mechanical equipments	0.352	3	6	6	3	2
Machine's factors	0.332	Validity of small manual or power machines and tools	0.342	1	3	3	8	5
		Validity of safe guarding appliances	0.307	3	4	7	4	2
		Climate operation conditions	0.351	1	2	3	9	5
Environment's factors	0.276	Dust operation conditions	0.314	1	1	5	8	5
		Operation conditions of work high above the ground	0.335	3	5	9	3	0

$$R_2' = \begin{bmatrix} 0.15 & 0.30 & 0.30 & 0.15 & 0.10 \\ 0.05 & 0.15 & 0.15 & 0.40 & 0.25 \\ 0.15 & 0.20 & 0.35 & 0.20 & 0.10 \end{bmatrix}$$

$$R_3' = \begin{bmatrix} 0.05 & 0.10 & 0.15 & 0.45 & 0.25 \\ 0.05 & 0.05 & 0.25 & 0.40 & 0.25 \\ 0.15 & 0.25 & 0.45 & 0.15 & 0.00 \end{bmatrix}$$

(2) Determining the correlation degree matrixes S_i'
By $S = RE^T$, S'_1, S'_2 and S'_3 can be obtained.

$$S_1' = R_1'E'^T = [0.40 \quad 0.63]^T$$

$$S_2' = [0.56 \quad 0.34 \quad 0.53]^T, S_3' = [0.31 \quad 0.31 \quad 0.60]^T$$

(3) Determining the relative correlation degree N'_i for each attribute index
By the matrix N = WS, the valid evaluation results of the system in our country are as follows.

$$N_1' = 0.519, \quad N_2' = 0.475, \quad N_3' = 0.409$$

9.3.3.4 The Whole Validity Evaluation of Man–Machine–Environment System

Because of N'_i, applying the undermentioned model, the whole evaluation value N' can be computed.

$$N' = \sum_{i=1}^{3} N_i \times W_i = 0.474$$

9.3.3.5 Judging the Validity Results of Man–Machine–Environment System

By the evaluation calibration, the conclusion can be made that the building operations' man–machine–environment system in our country is very valid when N is equal to 1. When N is less than 1 and more than or equal to 0.75, the system is valid. When N is less than 0.75 and more than or equal to 0.5, the system is relatively valid. When N is less than 0.5 and more than or equal to 0.25, the validity of the system is common. When N is less than 0.25 the validity of the system is bad.

Therefore, by the foregoing evaluation results, the whole validity of man–machine–environment system in our country is common. And the human factors are relatively valid. The validity of machines and environment factors are both common. In addition, the paper selects this construction enterprise of larger size, normative management, industry representativeness to carry out the investigation. So the evaluation result is representative in construction industry. Consequently, the operation conditions of construction enterprises in our country are widely poor. It's imminent to enhance workers' health, safety and comfort level, applying ergonomic principles, synthetically considering human, machine and environment factors.

9.4 Man–Machine–Environment System Improvements of Building Operations in Our Country

Aiming at the evaluation results of validity, some improvements are as follows.

9.4.1 Construction Laborers' Improvements

For the deficiency of laborers' technical level, government and construction enterprises should jointly take on the cultivation of construction laborers. In construction industry, the primitive mode of prentice training will be eliminated step by step. The double-core cultivation system of construction enterprises and schools will be set up. So construction laborers not only can operate, but also can comprehend theories. The will reach the technical level of modern construction laborers.

9.4.2 Construction Machines' Improvements

Construction laborers directly manipulate small manual or power machines and tools. So the machines and tools' rationality, applicability and convenience are the immediate factors influencing the work efficiency. The unscientific design of tools can't make laborers work with great facility. Laborers are certainly inefficient and at the same time occupational injuries are inevitable.

Aiming at the inefficient problem of small manual or power machines and tools, developers and manufacturers should cooperate with construction enterprises. The participation of construction enterprises can make developers and manufacturers absorb more innovations and suggestions about more scientific and better tools.

9.4.3 Construction Environments' Improvements

9.4.3.1 Climate Environment Improvements of Building Operations

For high or low temperature operations, except for the conventional laborer conservation measures, maintenance of machines must be strengthened simultaneously. Aiming at seasonal rainy season and the other climatic conditions, construction plans should be arranged with reason. Before rainy season, these constructions can be ended or come to a conclusion in order to lessen the influence to project process. Interior finish project and the other projects can be carried out in rainy season.

9.4.3.2 Dust Environment Improvements of Building Operations

Aiming at the traits of building operations, the corrective measures of dust environment are mainly as follows (Xiong 2009).

(a) Construction sites introduce rationalization management. Aggregates are intensively stacked. Cement should be stacked in special storehouses. And transportation should be as little as possible. Materials should be transported lightly to prevent the packages bursting.
(b) When excavating, working sides and mounds should be watered moderately to keep certain humidity in order to reduce dust emission. And the excavated earth and building rubbish should be carried away to prevent surface drying due to long-term stacking. The dry surface can be dusting or eroded by rainwater.
(c) Haulage vehicles should not be loaded too heavily. Shelters and protective measures are adopted in order to reduce rubbish casting along the road. The earth and construction materials scattered on the road should be swept in time. Washing tires and periodically watering to prevent dust in order to lessen the floating dust in transportation process.
(d) The commercial concrete is the first choice to use. If mortar and concrete need be mixed in site, dropping, leaking, remaining and tipping should be rooted out. Concrete mixing should be done in a shed and have spraying water measures.
(e) Stockade and partial stockade should be set to shrink the scatter range of construction dust.
(f) When wind velocity is too rapid construction operation should be stopped and the shelter measures for building materials should be adopted.

9.5 Conclusion

This paper designs the thinking of analysis–evaluation–improvement for man–machine–environment system of construction operation in our country. And principally grasps the whole validity of the man–machine–environment system. The evaluation results show that the whole validity is common. The urgent problems are mainly reflected in the following: technical level of operation, validity of small manual or power machines and tools, climate and dust operation conditions. This is a complicated systems engineering to solve these problems. It needs the cooperation of construction enterprises and talents training institutions to train talents. It also requires construction enterprises, developers and manufacturers to jointly produce machines and tools. At the same time solving these problems needs thinking over cost and combining construction technology to improve climate and dust conditions.

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Chapter 10
The Determining Method of Cashiers Working Fatigue Point Based on Performance Measurement

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Abstract The performance measurement method is used to analyze the characteristics and regular pattern of supermarket cashiers working fatigue in this paper. Firstly, the working fatigue point of cashiers is defined and the required time for scanning single commodity is selected as performance indicator. Secondly, the reliability analysis and single factor variance analysis are applied to the actual measurement data of performance indicator. Then, based on two-hand process analysis of cashiers, the standard time of scanning single commodity is calculated by mod method. Finally, the working fatigue point of cashiers is determined by using Xbar-R control chart. In order to demonstrate the utility of the proposed approach, the fatigue of supermarket cashiers is investigated with questionnaire. This study shows the relationship between the cashiers working efficiency and the fatigue degree and supplies the foundation of setting the timetable for cashiers.

Keywords Cashiers · Control chart · Fatigue point · Mod method · Working performance evaluation

10.1 Introduction

Fatigue is a kind of subjectively unwell feeling, which refers to a phenomenon of failing labor function, reducing work capacity and associating with the subjective symptom like tiredness in the process of laboring (Guo and Qian 2005). The operation of supermarket cashiers has the features of manual, monitoring and static. The cashiers always stand with a relatively stereotypic posture. They take various commodities and scanners by hands and meanwhile cashiers have to

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concentrate on reacting to all kinds of information in the screen quickly and exactly. While keeping the status for a long time, the cashiers will feel nervous in neuron and local muscles (Gao 2007). Besides, the working is largely restrained by customers, working space and devices with a lack of autonomy. The body accepts some environment information such as the temperature, noise and air quality in supermarket passively, which has a bad effect on human physiology and psychology. In this case, the fatigue feeling of cashiers is aggravated (Jay et al. 2008). The accumulated fatigue will lead to low efficiency and high operation error rate, and even endanger the health of cashiers. Through studying the fatigue feeling of cashiers and judging whether they keep in a state of fatigue or not, people can take reasonable measures to prevent and control, to reduce the fatigue degree and improve the working efficiency.

The fatigue measurement provides the premise and foundation of the fatigue analysis (Chen et al. 2011). A large amount of studies on manual, monitoring and static working fatigue have been made by scholars both at home and abroad, including different kinds of influence factors of fatigue, evaluation methods, fatigue improvement and so on (Ding et al. 2006; Tewar et al. 2004; Uetake et al. 2000; Ma and Chablat 2010; Park and Gi 2012). The fatigue measurement mainly contains subjective evaluation method, physiological parameters test method, biochemical test method, psychology test method and the comprehensive test method combined with them. The analysis and evaluation methods of working fatigue in the existing research are mostly proposed based on people's physiology, psychology index and subjective feeling, which result has strong practicability and reliability. However, the result can not reflect the characteristics and regular of fatigue from the view of working performance. The fatigue status of cashiers in supermarket is studied with performance measurement method. The methods of judging whether cashiers fatigue or not by determining the working fatigue point are presented in this paper.

10.2 Methodology

10.2.1 The Definition of Working Fatigue Point

Working fatigue point refers to the working time of efficient dropping with the lasting working in the process. It's the symbol of working fatigue that can be used to judge whether workers are fatigue. According to the accumulation status of fatigue, people's working process can be divided into four stages: working adaptation period, best working period, fatigue period and accumulation period of over fatigue (Guo and Qian 2005). In the first stage, people's abilities are not inspired, they would keep in a state of overcoming body inertia, and the working efficiency is low and there is no fatigue feeling. Then, human body adapts to the working environment gradually and the working efficiency reaches a best state and will last a long time. While after the best working period, people begin to feel fatigue and the working speed and accuracy begin to decrease with the dropping of efficiency and quality. If the workers do not take a rest or adjust activity intensity when feel fatigue, it would make over-accumulate of fatigue. Then the workers would lose the working ability temporarily. The theory above-mentioned provides the basis to determine fatigue point through performance measurement.

10.2.2 Analysis and Measurement of Performance Indicator

There are two key aspects that ensure the successful implementation of working performance measurement method. One is the reasonable performance indicator, and the other is the scientific measure method. The working performance indicator often includes the quantity and quality of finishing work, reacting speed, and accuracy rate and so on. The indicator should be selected to present the fatigue state of workers objectively and quantitatively with considering the working features and demands. The measure method requires that the additional fatigue, the subjects' unpleasant or psychological burden cannot be generated during measuring. Usually the cashiers operate as follow: firstly, taking out the commodities from shopping basket; secondly, scanning the commodities one by one; thirdly, cashiering with cash or credit; fourthly, helping customers to put commodities into shopping basket. If the performance indicator is the time that finished all of above operations, it cannot explain the fatigue degree, as the result is affected by the number of commodities customers buying, types of payment and some other factors. Therefore, the time of scanning single commodity can be chosen as performance indicator and can rule out other factors' influence effectively.

Stopwatch method is adapted to measure the time of scanning single commodity, which starts from the moment that the cashier's left hand reaching to the commodity and stops when finishing scanning with putting commodity down. The required time of scanning each commodity in fifteen minutes selected from each hour is formed a set of data. There are totally eight sets of data through measuring one working shift (eight hours) continuously. By reasons of the errors that caused by reacting time of measurers and other accidents, the reliability analysis must be processed to measured data. So the average of each set of data are counted and the most closed six data to average are selected as one set, which can obtain the reliable data of scanning single commodity.

Single factor variance analysis is used to test the efficiency and relevance between the indicator data and fatigue. Suppose that the time of cashiers' finishing the same working conforms to normal distribution, the variance of each population keep the same and every measured value should be independent (Yuan et al. 2000). Here, single factor variance analysis is used with the accumulation of fatigue as independent variable and the time of scanning single commodity as dependent variable. If F is the testing statistics parameter, F_α is the critical value of the given significance level α. When $F > F_\alpha$, the testing factor, which is accumulation of fatigue, has a significant impact to observed value, which is the time of scanning single commodity T_s.

10.2.3 Determination of the Working Fatigue Point

Once verifying the existing significant impact between accumulation of fatigue and T_s, the fatigue point of cashiers can be determined. Suppose the cashiers do not feel fatigue in one shift, T_s is only influenced by some random factors. The average and range of T_s should both keep stable and wave in a certain range. However, due to the influence of the fatigue and other systematic factors during the real working, T_s appears exception in a certain moment and moves out of the normal interval. Therefore, on the premise of ruling out other systematic factors, the fatigue point can be judged according to the time that T_s moves out of the control interval.

The control chart is used to determine the controlled interval of T_s. The chart is an important method and tool to make statistical quality management. It is made up of a series of measure points in order of time and rectangular coordinate. The rectangular coordinate has three main parallel lines. The center solid line is center line (CL). The upper dotted line is upper control limit (UCL) and the lower one is lower control limit (LCL) (Wu 2006). The interval between the upper and lower control limit is the controlled interval. The principle of judging cashiers working fatigue point by using the control chart is when T_s values are more than the controlled interval in control chart, the point is determined as the working fatigue point.

The concrete steps of drawing the control chart are as follow. Firstly, the standard value of the time of scanning single commodity is determined by using the mod method (Yi and Guo 2007). And the value is used to substitute the average of T_s. Secondly, the maximum, minimum and range value of each set of sample testing values are calculated. The next step is to calculate the upper and lower bounds of average chart and variance chart according to relevant formulas. Finally, the center line and upper and lower control limit are drawn and the control chart is generated.

10.3 Results

10.3.1 The Analysis and Calculation Results of Data

This survey and measurement are performed separately in Carrefour from 8:00 to 16:00 in October 2, 3, 4, 2011. The available measured data is showed in Table 10.1, which is obtained after making reliability analysis and processing of the original measured data. The results of single factor variance analysis about the data can be seen in Table 10.2. As the significance level α equal to 0.05 and critical value $F_{0.05}(7, 40)$ equal to 2.25, F is greater than F_{α}, it means that the cashiers fatigue accumulation has significant effect in the time of scanning single commodity.

Table 10.1 Timetable of scanning single commodity

Group	1	2	3	4	5	6	7	8
1	1.78	1.89	1.48	1.84	1.82	2.25	2.55	1.91
2	1.77	1.81	1.49	1.82	2.01	1.90	2.35	2.03
3	1.76	1.75	1.64	1.64	1.81	2.19	1.95	1.98
4	1.89	1.87	1.67	1.95	2.25	2.02	1.98	2.23
5	1.81	1.74	1.6	1.78	2.15	2.01	2.08	2.28
6	1.88	1.67	1.73	1.73	1.92	2.19	2.23	1.91
Mean	1.82	1.79	1.60	1.79	1.99	2.09	2.19	2.06
X_{max}	1.89	1.89	1.73	1.95	2.25	2.25	2.55	2.28
X_{min}	1.76	1.67	1.48	1.64	1.81	1.90	1.95	1.91
Range	0.13	0.22	0.25	0.31	0.44	0.35	0.6	0.37

Table 10.2 The variance analysis of the scanning time

Differences source	SS	df	MS	F	P-value	F crit
Interblock	1.38	7	0.20	8.53	2.32	2.25
Interclass	0.92	40	0.02			
Total	2.30	47				

The standard time of scanning single commodity is calculated by the mod method. Suppose that scanning starts from the two hands of cashiers are idle and the scanner is fixed, the cashiers just need to aim the bar-code of commodity at the scanner. The operation of scanning single commodity and the mod method analysis on the process is shown in Table 10.3. It shows that the mod value of the whole scanning process is 13MOD.

$$T = 13 \times 0.129 = 1.667s$$

Here T is the theoretical time of finishing once scanning; it can be used as the standard time simply without considering the relevant factors.

Table 10.3 MOD method analysis of the scanning time

No.	Movement of right hand	Movement of left hand	Sign flag	Time	MOD
1	Free	Reaching for the commodity	M3G1	1	4
2	Free	Moving to the scanner	M3	1	3
3	The bar-code aiming at the scanner	Holding the commodity	R2	1	2
4	Scanning	Holding the commodity	G1	1	1
5	Moving and putting down the commodity	Free	M3	1	3

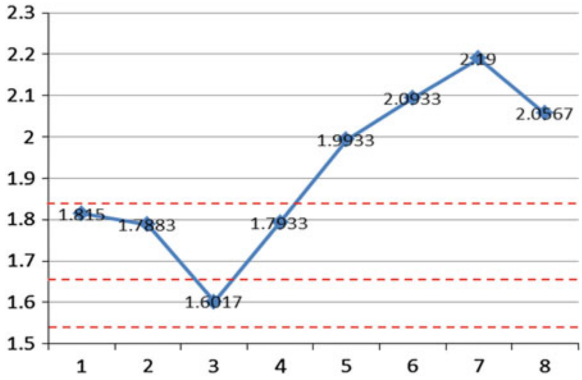

Fig. 10.1 The X-bar control chart of scanning time

10.3.2 The Result of Determining Working Fatigue Point

Xbar-R control chart is used to determine the working fatigue point in this paper. The lateral axis in the rectangular coordinate indicates the order of taking samples in time interval. The vertical axis indicates the time T_s of scanning single commodity of cashiers. The X-bar control chart is got by calculating the data in Table 10.1:

$$CL = 1.667s \quad UCL = \overline{X} + A_2 \times \overline{R} = 1.824s$$

$$LCL = \overline{X} - A_2 \times \overline{R} = 1.530s$$

The range control chart can also be obtained:

$$CL = 0.334s \quad UCL = D_4 \times \overline{R} = 0.611s.$$

When n less than or equal to 6, D_3 is negative, so the LCL is not considered here. X-bar and R control chart is drawn as Figs. 10.1 and 10.2.

As Fig. 10.1 shows, the cashiers working performance is on the rise in the first three hours. The average of T_s value drops from 1.815 to 1.6017 s, which means

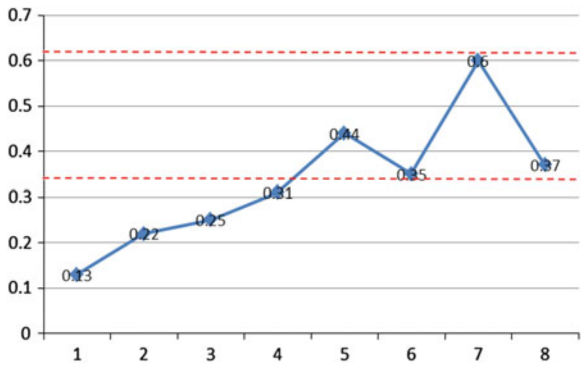

Fig. 10.2 The range control chart of scanning time

that the cashiers change from working adaptation period to the best working period. With the continuous operation, the working performance of cashiers begins to drop with T_s value rising slowly. About four hours and ten minutes later, the T_s value rises over upper control line, which the moment is determined as working fatigue point.

10.4 Discussion

The work of supermarket cashiers has the obvious feature of monotonous with the requirement of high speed and accuracy. The cashiers easily feel fatigue on spirit and body. With work preceding, the fatigue produces and develops, which has the cumulative effect. Through determining the working fatigue point, the fatigue state can be easily judged. Once the workers step into the fatigue period, reasonable work and rest schedule must be applied to recover the worker ability and reduce the fatigue feeling (Yen et al. 2009). Besides, the working efficiency and quality can be improved.

The measurement of working performance do not need to interpret the activity and test the workers' physiological and biochemical parameters. However, it is lower accurate to judge the fatigue by single using the working performance indicator because the sign of dropping performance caused by fatigue is covered by the practice effect and stimulation of alternating working which improves the level of brain activity. In this study, the T_s value shows dropping in the last one hour, which is also evidence. On the basis of working performance measuring, linked with the subjective evaluation and psychological index evaluation, the judging inaccuracy of fatigue caused by single-index testing error can be effectively avoided (Leunga et al. 2005). The cashiers fatigue is investigated with questionnaire in this study. The result shows that the subjective feeling of cashiers' fatigue is affected by working strength, time, posture, individual situation and so on. About 76 % of cashiers feel obvious fatigue after working four hours and 12 % of cashiers have no feeling of fatigue in a working period.

It's practicable to determine the fatigue point by using control chart from the point of theory and practice. However, there may be two types of faults: one is the misjudgment caused by the T_s value moves out of control range occasionally; the other is the leak judgment caused by the T_s value keeps in the control range although producing fatigue. The occurring of the two types of faults depends on the width of control limit, the degree of losing control in process and the number of testing groups. The best distance can be determined through selecting suitable control chart and adjusting the distance between control chart UCL and LCL according to the data of fact reasonably.

10.5 Conclusion

The time of cashiers scanning single commodity in day shift is measured and the single factor variance analysis of the testing data is presented in this paper. So the relationship between cashiers' working fatigue and work performance indicator is reflected. Based on calculating the standard scanning time by using mod method, the cashiers working fatigue point is determined by control chart, that is four hours continuous working. The result reflects the regular pattern that the cashiers working efficiency changes with the fatigue degree and provides the foundation of setting the timetable of cashiers. In the premise of effectively controlling the influence factors of working performance, and selecting different performance evaluation indicators reasonably, this method also can be used to study other similar workers fatigue, such as the production line process or assembly operation (Lamkull and Hanson 2009).

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Chapter 11
The Quantitative Effects of Mattress and Sleep Postures on Sleep Quality

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Abstract Mattress, as a sleep platform, its types and physical properties have important effects on sleep quality and rest efficiency. In this paper, by subjective evaluations, analysis of sleeping behaviors, the relationship between the sleep postures, change postures and sleep quality were studied. The results showed that: (1) the mattress properties had a remarkable effect on sleep behaviors and sleep quality; (2) Sleep behaviors had a close relationship with sleeping postures and sleep habits. The characteristics of sleep behaviors vary from person to person; (3) Chinese people had tended to prefer supine posture, and the number of turns during night was less in supine position than in the lateral position.

Keywords Mattress · Sleep movements · Sleep postures · Sleep quality

11.1 Introduction

Although the use of western-style mattress has been accepted by more and more Chinese people, there exist few intensive studies on mattress properties and Chinese demands. Compared with traditional beds, western-style mattresses seem to

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have brought more sleep disturbances and health problems. A survey of the US public concerning the quality of sleep has showed that 7 % of the subjects indicated that their sleeping problems were related to an uncomfortable mattress (Addison et al. 1986). Among them incorrect sleeping postures and insufficient support conditions, especially insufficient support of the low back was one of the most important factors causing low-back pain (Hildebrandt 1995). Park et al. have reported that the comfort of a bed was more heavily influenced by secondary properties, such as spinal curvature and distribution of body pressure in Human-Bed system than the primary properties of the material of mattress itself. However, these studies have not provided evidence that sleep quality differs according to mattress properties (Lee and Park 2006).

Lee and Park (2006) studied the effects of "comfortable" and "uncomfortable" mattress, although they did not find differences in sleep architecture, their experimental results showed that "comfortable" mattresses could help to reduce the movements in the stage of deep sleep (Lee and Park 2006). In fact, sleep is a complex phenomenon; sleep quality is affected by a combined action of physiological factors psychological factors and external environments.

The objective of this study was to investigate the Chinese people's demands on mattress and the relationship between the sleep postures, mattresses and sleep quality.

11.2 Methodology

Each subject was recorded at least 4 consecutive nights (starting on Monday night and ending on Friday morning) on each of the 18 mattresses. The subjects were blind to the bedding materials and structure of spring mattress. Two weeks prior (Jacobson et al. 2008) to the test all participants were asked to sleep in the sleep laboratory to adapt the laboratory conditions and maintain a constant life style without change in sleeping habits. The temperature and relative humidity in the sleep laboratory was controlled at 25 ± 1 °C and 50 ± 5 %, respectively. To minimize the seasonal influence on sleep quality (Kleitman 1939), the test took place from September to December.

(1) *Subjects*: The subjects, participating voluntarily in the study, had good health, simple life style, regular sleep habits, no history or symptoms of sleep disorders, and were not heavy snorers. The participants were required to sleep still on the experimental mattress during each testing cycle. No medicine, tea, coffee, and other stimulating beverages were allowed 3 h prior to the sleeping test. Volunteers were 11 female graduate students, age of 20–32 years. Average height, weight, and body mass index were 159.81 cm (± 9.88 cm), weight 51 kg (± 6.5 kg), and 20.2 (± 3.3), respectively.

(2) *Body movements during sleep*: Subject body movements were recorded in the dark using Ingra-red video cameras and meanwhile observed by the technicians outside of the sleeping room through monitors.

(3) *Sleep diaries and visual analogue Scales (VAS)*: A self-report of sleep was measured with a sleep diary that was filled out each morning immediately upon arising. The subjects needed to answer questions about any external disturbance during the night, the subjective quality of sleep, the level of fatigue and sleepiness, the location of the occurrence of discomfort or pain, perceived the number of awakenings, the degree of easily falling asleep, mattress stability. The subjects also needed to provide 7-level VAS scores each morning reflecting the comfort degree of different parts of human body.

(4) Selection of mattress: Eighteen mattresses were provided by Nanjing Kirin Co., Ltd. According to the CTBA standard, the compressive mechanical properties of the mattresses were obtained and the rigidity of mattresses was 76.5 ± 26.1 mm.

(5) *Analysis*: Prior research on sleep surfaces had suggested that a time frame of up to 4 nights or more may be required before a sleeper accommodates to a new sleeping surface in their home (Jacobson et al. 2008; Bader and Engdal 2000; Scharf et al. 1997). Therefore, data for VAS, sleep diary, sleep structure and movement parameters were analyzed from the fourth day to the seventh day of sleeping on one mattress, the first three night's record were not used. Correlations between variables were made with Spearman. To compare sleep quality between 18 different mattresses, the F-test for each pair of variables from all the recorded nights for the 18 mattresses conditions was used. Differences of $p < 0.05$ were considered significant for all statistical analyses.

11.3 Results

11.3.1 Sleep Postures

The amount of movements varied among the subjects, but the individual movement pattern had some reproducibility from night to night, providing that the activity and the stress during the day were moderate and that the subjects did not experience discomfort or pain during the night except sleeping on the mattress with poor stability or with top layers of too high hysteresis.

Table 11.1 gives mean values of the number of turns and adopted sleep postures and their standard deviations of 18 experimental mattresses tested by 11 subjects. For 11 subjects, the mean of the number of changing postures per night was 18.72. The average amount of time per night that spent in supine posture (53.02 %) was longer than that in lateral posture (45.88 %). The average amount of time per night that spent in the left side posture was slightly longer than that in the right side posture. The average amount of time per night that spent in prone posture was very short (1.09 %).

The number of turns presents negative correlation with the average amount of time per night that spent in supine posture and presents positive correlation with the average amount of time per night that spent in lateral posture and prone posture

Table 11.1 Mean values of the number of turns and adopted sleep postures during overnight experiments

The number of turns		Sleep postures				
		Supine (%)	Lateral on the left side (%)	Lateral on the right side (%)	Lateral (%)	Prone (%)
Mean	18.72	53.02	24.96	20.93	45.88	1.09
SD	7.74	16.95	13.96	13.04	16.76	3.56

Note The data in the table are the mean and the standard deviation for 18 mattresses and 11 subjects

Table 11.2 Correlation between the number of turns and sleep time in every posture

	The number of turns	The % time in supine position	The % time on the left side	The % time on the right side	The % time in lateral position	The % time in prone position
The number of turns	1	−0.329**	0.174**	0.203**	0.297**	0.295**
The % time in supine position		1	−0.615**	−0.533**	−0.974**	−0.128**
The % time on the left side			1	−0.244**	0.624**	−0.031
The % time on the right side				1	0.554**	−0.023
The % time in lateral position					1	−0.034
The % time in prone position						1

Note ** Mean data are significant correlation (2-tailed) at the 0.01

(Table 11.2). There was significant negative correlation between the average amount of time per night that spent in supine posture and lateral posture (Table 11.2). In other words, the longer the time that spent in supine posture was, the less the number of turns was.

11.3.2 Subjective Sleep Quality and its Factors

Sleep comfort presents positive correlation with adequate sense of sleep quantity, the degree of easily falling asleep, the degree of easily falling asleep after awake during sleep period time, satisfaction with mattress, body status in the next morning, stability feeling of mattress, and had negative correlation with dreaming quantity, perceived the number of awakening and fatigue in the next day, in which the correlation between sleep comfort, adequate sense of sleep quantity, body status in the next morning, satisfaction with mattress and stability feeling of mattress was stronger than others (Table 11.3).

There were significant correlations between the lumbar comfort, the buttock comfort, the upper leg comfort, the knee comfort and the lower leg comfort, especially the comfort of adjacent parts of human body shows closer relationship (Table 11.4).

11.3.3 The Correlations Between the Mattress Mechanical Characteristic and Sleep Quality

There were significant differences in the subjective sleep ratings scores (Fig. 11.1) among 18 tested mattresses. There was a mild trend showing that the subjective sleep quality increased as mattress firmness decreased, although most of the subjects felt a little too soft for some of the experimental mattresses in the adapted period (prior to the test).

11.4 Discussion

The influence of different postures (Dolan et al. 1988) is an important determinant of human body support. Optimizing body posture in both conscious and unconscious ways ensures continuous spine protection (Farfan and Gracovetsky 1984)· But instead of creating perfect conditions to allow optimizing our body position in an unconscious way, the sleep system actually forces us into a certain position. Body position is therefore limited to an initial conscious selection and subsequent unconscious optimization. Furthermore, posture changes are necessary to avoid pressure overloading of soft tissues and to prevent muscle stiffness. During sleep a local ischemia—a deficiency of blood or oxygen supply—will arise in body zones that are in contact with the sleep system. This ischemia generates metabolic substances that stimulate the sensible nerve extremities, which will cause the person to change his or her posture before it gets painful (Dzvonik et al. 1986).

The main advantage of sleeping in a supine position is the fact that body weight is distributed over a large surface, resulting in pressure distribution and stability being optimized. The lumbar part of the vertebral column will mostly be positioned between a smoothed lordosis and a slight kyphosis, depending on (1) the kind of sleep system, (2) the natural curves of the spine, and (3) muscle tension while sleeping. When a mattress is too soft, places where body weight is concentrated (e.g., the hip zone) will sink deeply into the mattress. Some muscles may be well relaxed in this position, but the spine certainly will not; the pelvis will

Table 11.3 Correlation between the parameters of subjective sleep quality

	SC	ASSQ	DEFA	DQ	NA	DEFAA	SM	BSNM	FND	SFM
SC	1	0.625**	0.333**	−0.291**	−0.281**	0.303**	0.493**	0.616**	−0.454**	0.443**
ASSQ		1	0.315**	−0.113**	−0.138**	0.211**	0.376**	0.531**	−0.428**	0.376**
DEFA			1	0.065	−0.111**	0.249**	0.258**	0.299**	−0.207**	0.512**
DQ				1	0.240**	−0.035	−0.180**	−0.297**	0.221**	−0.382**
NA					1	−0.253**	−0.125**	−0.199**	0.176**	−0.561**
DEFAA						1	0.194**	0.258**	−0.327**	0.499**
SM							1	0.575**	−0.275**	0.458**
BSNM								1	−0.419**	0.298**
FND									1	0.266**
SFM										1

Note ** Mean data are significant correlation (2-tailed) at the 0.01
SC sleep comfort, *ASSQ* adequate sense of sleep quantity, *DEFA* the degree of easily falling asleep, *DQ* dreaming quantity, *NA* perceived the number of awakening, *EFAA* the degree of easily falling asleep after awake during sleep period time, *SM* satisfaction with mattress, *BSNM* body status in the next morning, *FND* fatigue in the next day, *SFM* stability feeling of mattress

Table 11.4 Correlation between parts comfort of human body in the next morning

	Neck comfort	Arm comfort	Shoulder comfort	Back comfort	Lumbar comfort	Buttock comfort	Upper leg comfort	Knee comfort	Lower leg comfort
Neck comfort	1	0.419**	0.459**	0.289**	0.166**	0.312**	0.338**	0.256**	0.319**
Arm comfort		1	0.494**	0.275**	0.129**	0.435**	0.427**	0.300**	0.301**
Shoulder comfort			1	0.301**	0.211**	0.310**	0.355**	0.271**	0.302**
Back comfort				1	0.413**	0.319**	0.241**	0.158**	0.184**
Lumbar comfort					1	0.312**	0.221**	0.165**	0.213**
Buttock comfort						1	0.656**	0.388**	0.495**
Upper leg comfort							1	0.647**	0.730**
Knee comfort								1	0.737**
Lower leg comfort									1

Note ** Mean data are significant correlation (2-tailed) at the 0.01

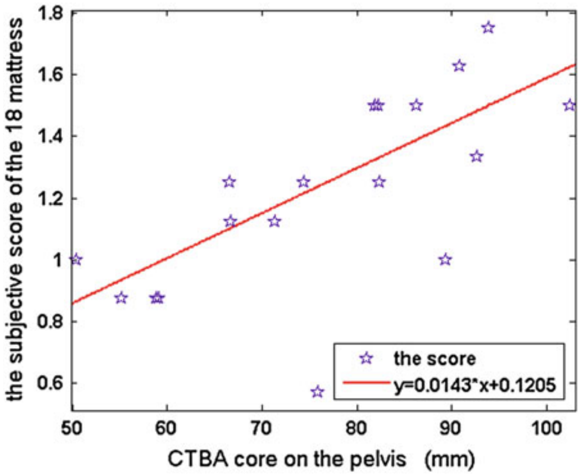

Fig. 11.1 Mean of the subjective rating scores given by participants in the sleep study (overall sleep quality)

cant backward resulting in a complete and unnatural lumbar kyphosis. When a sleep system is too firm, the lumbar part of the vertebral column will not smoothen immediately when lying down, and no contact will be made between the lumbar part of the back and the mattress. Upon muscle relaxation (which occurs after 10 to 15 min on average) the pelvis will cant backward slightly, which results in a slight smoothing of the lumbar part of the vertebral column. Some persons might however experience discomfort due to muscle tension that arises when the pelvis cants backward while the legs stay in a horizontal position (Haex 2005).

The lateral position is the most sleeping posture that European adopted, and it is able to support the human spine correctly when both the bed and pillow are well conceived: the spinal column is a straight line when projected in a frontal plane, while natural curves are maintained. Due to decreased contact surface and the center of gravity being more elevated, a lateral position is an unstable sleep position, which can be altered by the correct positioning of the extremities. Bending arms and legs enlarges the support area and thus improves stability.

According to our results it was found that the amount of time spent in each sleep posture to Chinese subjects was significant different from that of European subjects, Chinese people preferred to sleep in supine posture (53.02 % of the amount of time spent in supine posture), while European had a preferred side to sleep on and the amount of time spent in supine posture was less than 30 % (Verhaert 2011). From the point of view of ergonomics, the demand of the mechanical properties of mattresses should be different to the people with different preferences in sleep posture.

Our results also showed that sleep quality was different when subjects slept on spring mattresses with different characteristics of the bedding materials and structure, and the sleep movements and posture changes was relevant to the preferred sleeping posture. Sleep quality was related to sleep comfort, while sleep comfort was affected by the external factors such as the spirit state before sleeping (or the degree of easily falling asleep), adequate sense of sleep quantity and satisfaction with mattress use and so on. And sleep quality will influence badly the body status in the next day. To the unzoned mattress, the lack of effective support of waist and pelvic was an important factor effecting the use comfort of the mattress.

11.5 Conclusion

These results showed the difference of sleep quality when subjects slept on mattress with different properties. The sleep movements and change postures were related with the sleep postures. The number of change postures was less in supine posture than in lateral posture. The Chinese preferred the sleep posture in supine position. Further investigations are required with the factors of the mattress stability and instability patterns.

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Chapter 12
A Research on Manufacturing Grid Resource Pricing Strategy Based on the Option Contract

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Abstract According to the option features that manufacturing grid resource has, this paper builds resource pricing model based on the option contract transaction. First the profits of the resource demand-sides gained by purchasing resources through option contract or directly from spot market are compared, then the condition of option contract parameters that should satisfy is obtained and the analytical solution to the optimal contract purchasing quantity for the demand-sides is deduced. Afterwards the optimal parameters of the option contract are solved in programming model of the resource supply-side built by using the game theory. Finally an example is given to illustrate the use of the model and to verify its superiority.

Keywords Execution price · Manufacturing grid · Manufacturing resource · Option contract · Reservation price

12.1 Introduction

Manufacturing grid is to utilize grid technologies, information technologies, computer and advanced management technologies, etc., to conquer the barrier resulting from spatial distance in collaboration among different corporations to

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make all kinds of dispersive manufacturing resources to be fully connected (Tao et al. 2006).

In manufacturing grid, manufacturing resources are shared in the form of grid services. The resource providers of the grid services hope to get as much economic benefits as possible, while the resource demand-sides who use the grid services want to pay as little as possible, so resource pricing is directly related to the effectiveness of the manufacturing grid resource management and scheduling strategy.

Currently grid resource management has involved a certain content of the resource pricing. It is mainly related to the use of market economy models, and the GRACE (Grid Architecture for Computational Economy, put forward by Grid Economics Research Group led by Rajkumar Buyya in Melbourne University, Australia) is the most representative (Rajkumar 2002; Rajkumar et al. 2004), which simulates the reality of market economy mechanism and introduces a number of different economic models of commodities in order to achieve effective resource management. These models reflect the respective pricing strategies and price factors. But the prices obtained by them are the equilibrium prices affected by grid market participants, without taking into account the uncertainties and execution risks, thus can not reflect the true value of the resource.

Due to the dynamic changes of the grid environment, resource supply and demand sides are facing certain risks. On the one hand, the demand-side faces the risks that manufacturing task is not assigned to the resource which causes serious losses and the high price under the inadequacy; On the other hand, the supply-side faces the risks that resource is in the idle state and not assigned which causes losses and the low price under the oversupply situation. Moreover, grid resources are special commodities, similar to the power resources, that many are non-storable, with strict time characteristic. In grid economic environment, the example that a task will use resources at some point in the future is very common, so the market mechanism of resource reservation based on contract is more meaningful for the grid task (Cheliotis et al. 2003; Kenyon and Cheliotis 2002). As option has some reservation function with strong timeliness and for contract owners, option contract gives them the rights to execute the contract not the obligations to execute, so it has great flexibility to a certain extent, which can better adapt to the changes of market price and demands. In addition, option contract has been used in electricity market (Bessembinder and Lemmon 2002; Wu et al. 2002; Kleindorfer and Wu 2003; Shen and Pang 2004; Nina Yan and Liguo Zhou 2010) and supply chain (Chen 2006; Chen and Zhu 2007; Sheng and Ji 2008) which are similar to the grid market, so the model seems very suitable in grid environment.

In view of the option features that manufacturing grid resource has, this paper introduces the option contract model to characterize the problem of resource trading and resource pricing, and models and analyses in view of a kind of option, in order to examine the decision-making process of the parameters of the option contract. The two parameters (reservation price, execution price) involved in the option contract are the costs of using manufacturing resource by the option contract, which are also the targets required to be solved.

12.2 The Construction of the Option Contract Model in Grid Environment

12.2.1 The Model Parameters and Assumptions

Suppose a manufacturing grid is composed of a number of resource-based node enterprises, in which there are m resource supply-sides and n resource demand-sides. Investigate the option contract transaction among a certain resource supply-side p and its corresponding multiple resource demand-sides u_i $(i = 1, \ldots, n)$ in a certain period.

In the contract market of the first stage, the supply-side p decides reservation price (r) and execution price (e) of the option contract (r, e), then the demand-sides u_i decides the quantity of the option contract to purchase (Q_i) according to the relevant information provided by the supply-side. To the spot market of the second stage, the demand-sides u_i determines the quantity of the option contract to execute (q_i) and how many resources need to be purchased from the spot market (x_i) depending on the demand and the spot price; the supply-side p sells the excess manufacturing resource to other demand-sides.

In order to determine the values of the relevant parameters involved in the decision-making process, we introduce the following auxiliary parameters:

p_i	Market price of u_i's product
D_i	Market demand for u_i's product. If a unit product needs a_i units manufacturing resource, then the total resource demand of u_i is a_iD_i
TC_i	Total cost of the resource demand-sideu_i
$\prod_{ui}$	Profit of the resource demand-side u_i
c	Production cost of a unit manufacturing resource provided by the resource supply-side p
$\prod_p$	Profit of the resource supply-side p
p_s	Spot price of the manufacturing resource
M	Quantity of idle manufacturing resource, also the maximum quantity that the resource supply-side p can provide, satisfying $Q \leq M$, and $Q = \sum_{i=1}^{n} Q_i$

Taking into account the characteristics of grid environment and manufacturing tasks and the using issues of option contract, we assume the following:

Assumption 1: All the sides of the resource supply and demand are risk neutral.

Assumption 2: Resources provided by the supply-side are remaining available resources under the premise that local operating circumstances have been satisfied.

Assumption 3: In option contract market, a unit option contract corresponds to a unit manufacturing resource.

Assumption 4: In option contract market, both D_i and p_s are random variables with uniform distribution and independent of each other. The probability density function and the probability distribution function of p_s are $g(p_s)$ and $G(p_s)$. If D_i follows the uniform distribution of $[0, b_i]$, then the total resource demand a_iD_i follows a uniform distribution of $[0, a_ib_i]$, and the probability density $f(a_iD_i) = \frac{1}{a_ib_i}$, distribution function $F(a_iD_i) = \frac{a_iD_i}{a_ib_i}$.

Assumption 5: The decision-making behaviors of other participants in manufacturing grid don't change with the option contract among the supply-side p and the demand-sides u_i.

12.2.2 Establishing the Option Contract Model

(1) *The condition of accepting the option contract for the resource demand-sides*

For any demand-side, the optimization objective function of the purchasing strategy space (Q_i, x_i) is:

$$\max_{Q_i,q_i,x_i} E\prod\nolimits_{ui} = E(p_iD_i - TC_i) = E(p_iD_i) - E(rQ_i + eq_i + p_sx_i) \tag{12.1}$$

Due to $E(p_iD_i)$ be a fixed value, so the objective function can be converted into a cost function:

$$\min_{Q_i,q_i,x_i} E(rQ_i + eq_i + p_sx_i) \tag{12.2}$$

$$\text{s.t. } q_i = \min(Q_i, a_iD_i)\alpha(p_s - e) \tag{12.3}$$

$$\begin{aligned} x_i &= a_iD_i - q_i \\ Q_i, q_i, x_i &\geq 0 \end{aligned} \tag{12.4}$$

$$\alpha(p_s - e) = \begin{cases} 0 & p_s < e \\ 1 & p_s \geq e \end{cases} \tag{12.5}$$

Combine (12.3, 12.5), when $p_s \geq e \Rightarrow q_i = \min(Q_i, a_iD_i) > 0$, namely the demand-side will execute the option contract, and a unit option contract (r, e) can bring the demand-side $(p_s - e)^+ - r$ units benefits, $(p_s - e)^+ = \max(p_s - e, 0)$. When $p_s < e$, the demand-side will not execute any option contract at all, and the resources required will entirely buy from the spot market, and the net loss of a unit option contract is the reservation price r.

Therefore, only when the expected interest of the risk-neutral resource demand-side brought by purchasing a unit option contract is non-negative, namely $E\lfloor (p_s - e)^+ - r\rfloor \geq 0$, $\int_e^\infty (p_s - e - r)g(p_s)dp_s - \int_0^e rg(p_s)dp_s \geq 0$, $r \leq \int_e^\infty (p_s - e)g(p_s)dp_s$ the expectation of the portion that the spot price exceeds the execution price is greater than or equal to the reservation price, will the demand-side choose to accept the option contract; Otherwise, he should purchase and use directly from the spot market.

(2) *The optimal contract purchasing quantity of the resource demand-sides*

As the expected profit function of u_i is:

$$\begin{aligned} E\prod_{ui} &= E(p_iD_i) - E\left\{ \begin{array}{c} rQ_i + e\min(Q_i, a_iD_i)\alpha(p_s - e) \\ +p_s[a_iD_i - \min(Q_i, a_iD_i)\alpha(p_s - e)] \end{array} \right\} \\ &= E(p_iD_i) - E\left[rQ_i + p_sa_iD_i - (p_s - e)^+\min(Q_i, a_iD_i)\right] \\ &= p_iE(D_i) - E(p_s)E(a_iD_i) - rQ_i \\ &\quad + \int_e^{\infty}[1 - G(p_s)]dp_s \int_0^{Q_i}[1 - F_i(a_iD_i)]da_iD_i \end{aligned} \tag{12.6}$$

$$\frac{dE\prod_{u_i}}{dQ_i} = -r + \int_e^{\infty}[1 - G(p_s)]dp_s[1 - F_i(Q_i)] \tag{12.7}$$

$\frac{d^2E\prod_{u_i}}{dQ_i^2} = -\int_e^{\infty}[1 - G(p_s)]dp_sf_i(Q_i) \le 0$ always holds, thus, $E\prod_{u_i}$ is the concave function of the decision variable Q_i. So when $\frac{dE\prod_{u_i}}{dQ_i} = -r + \int_e^{\infty}[1 - G(p_s)]$ $dp_s[1 - F_i(Q_i)] = 0$,

$$Q_i = F_i^{-1}\left(1 - \frac{r}{\int_e^{\infty}[1 - G(p_s)]dp_s}\right) \tag{12.8}$$

$E\prod_{u_i}$, the expected profit of u_i gets the maximal value, and the value of Q_i is the optimal quantity of the option contract he should purchase, thus for all the resource demand-sides, their total optimal contract purchasing quantity in the contract market of the first stage is:

$$Q = \sum_{i=1}^{n} Q_i = \sum_{i=1}^{n} F_i^{-1}\left(1 - \frac{r}{\int_e^{\infty}[1 - G(p_s)]dp_s}\right) \tag{12.9}$$

(3) *Programming model of the resource supply-side*

Suppose the supply-side can sell $k(M - q)$ units redundant manufacturing resource in the spot market of the second stage $(0 \le k \le 1)$, so his profit function is:

$$\begin{aligned} \prod_p &= rQ + (e - c)q + (p_s - c)k(M - q) \\ &= rQ + (e - c)q - k(p_s - c)q + (p_s - c)kM, \quad q = \sum_{i=1}^{n} q_i \end{aligned} \tag{12.10}$$

Combine (12.3) and (12.5), the optimization objective function of the resource supply-side is:

$$\max E\prod\nolimits_p = rQ + (e-c)\sum_{i=1}^{n}\int_0^{Q_i}[1-F_i(a_iD_i)]da_iD_i\cdot[1-G(e)] \\ -k\int_e^{\infty}(p_s-c)g(p_s)dp_s\cdot\sum_{i=1}^{n}\int_0^{Q_i}[1-F_i(a_iD_i)]da_iD_i+[E(p_s)-c]kM \tag{12.11}$$

$$\text{s.t. } r\le\int_e^{\infty}(p_s-e)g(p_s)dp_s \tag{12.12}$$

Let $\omega = r-\int_e^{\infty}(p_s-e)g(p_s)dp_s$, then the nonlinear programming problem above can be simplified into the following form:

$$\begin{cases}\max E\prod_p \\ \omega\le 0\end{cases} \tag{12.13}$$

Write the gradients of its objective function and constraint:

$$\nabla E\prod\nolimits_p = \begin{pmatrix}\frac{\partial E\prod_p}{\partial r}\\ \frac{\partial E\prod_p}{\partial e}\end{pmatrix},\quad \nabla\omega=\begin{pmatrix}1\\ 1-G(e)\end{pmatrix} \tag{12.14}$$

Introduce a generalized Lagrange multiplier γ to the constraint, then the K-T conditions for the optimization problems are as follows:

$$\begin{cases}\nabla E\prod_p - \gamma\nabla\omega = 0\\ \gamma\omega = 0\\ \gamma\ge 0\end{cases} \tag{12.15}$$

According to $\gamma\omega = 0$ in (12.15), then $\gamma = 0$ or $\omega = 0$

$$\begin{aligned}&(1)\text{ If }\gamma=0,\quad\text{then }\nabla E\prod\nolimits_p=\begin{pmatrix}\frac{\partial E\prod_p}{\partial r}\\ \frac{\partial E\prod_p}{\partial e}\end{pmatrix}=0,\\ &\text{namely }\frac{\partial E\prod_p}{\partial r}=0\text{ and }\frac{\partial E\prod_p}{\partial e}=0\\ &(2)\text{ If }\omega=0,\quad\text{then }\begin{pmatrix}\frac{\partial E\prod_p}{\partial r}\\ \frac{\partial E\prod_p}{\partial e}\end{pmatrix}-\gamma\begin{pmatrix}1\\ 1-G(e)\end{pmatrix}=0,\\ &\text{namely }\frac{\partial E\prod_p}{\partial r}=\gamma\text{ and }\frac{\partial E\prod_p}{\partial e}=\gamma[1-G(e)].\end{aligned} \tag{12.16}$$

Take the former into the latter, there is:

$$\frac{\partial E\prod_p}{\partial e}=\frac{\partial E\prod_p}{\partial r}[1-G(e)] \tag{12.17}$$

And $\omega=0\Rightarrow r=\int_e^{\infty}(p_s-e)g(p_s)dp_s\Rightarrow Q=0$, thus all the resource demand-sides will not use the option contract to purchase the resources, and they will only buy from the spot market. Accordingly the resource supply-side p can only sell the idle resources through the spot market, and can sell kM units resources. Combine with (12.11), there is:

$$E\prod\nolimits_p=[E(p_s)-c]kM \tag{12.18}$$

12.3 Solving the Model

According to the results of the programming model of the resource supply-side, first solve r and e by (12.16).

$$\begin{aligned}\frac{\partial E\prod_p}{\partial r}&=Q+r\frac{\partial Q}{\partial r}+(e-c)[1-G(e)]\cdot\sum_{i=1}^{n}\left\{\frac{\partial Q_i}{\partial r}[1-F_i(Q_i)]\right\}\\&\quad-k\int_e^{\infty}(p_s-c)g(p_s)dp_s\cdot\sum_{i=1}^{n}\left\{\frac{\partial Q_i}{}[1-F_i(Q_i)]\right\}\\&=\sum_{i=1}^{n}Q_i+r\sum_{i=1}^{n}\frac{\partial Q_i}{\partial r}\\&\quad+\sum_{i=1}^{n}\left\{\frac{\partial Q_i}{}[1-F_i(Q_i)]\right\}\cdot\left\{(e-c)[1-G(e)]-k\int_e^{\infty}(p_s-c)g(p_s)dp_s\right\}\end{aligned} \tag{12.19}$$

$$\begin{aligned}\frac{\partial E\prod_p}{\partial e}&=r\sum_{i=1}^{n}\frac{\partial Q_i}{\partial e}+\sum_{i=1}^{n}\int_0^{Q_i}[1-F_i(a_iD_i)]da_iD_i\\&\quad\cdot\{[1-G(e)]+(k-1)(e-c)g(p_s)\}\\&\quad+\sum_{i=1}^{n}\left\{[1-F_i(Q_i)]\frac{\partial Q_i}{\partial e}\right\}\cdot\left\{(e-c)[1-G(e)]-k\int_e^{\infty}(p_s-c)g(p_s)dp_s\right\}\end{aligned} \tag{12.20}$$

Let (12.19) equals to 0, and simplify:

$$\left\{(e-c)[1-G(e)]-k\int_e^{\infty}(p_s-c)g(p_s)dp_s\right\}=-\frac{\sum_{i=1}^{n}\left(Q_i+r\frac{\partial Q_i}{\partial r}\right)}{\sum_{i=1}^{n}\left\{\frac{\partial Q_i}{\partial r}[1-F_i(Q_i)]\right\}} \tag{12.21}$$

Take (12.21) into (12.20) = 0, and simplify:

$$r\sum_{i=1}^{n}\frac{\partial Q_i}{\partial e}+\sum_{i=1}^{n}\int_0^{Q_i}[1-F_i(a_iD_i)]da_iD_i\cdot\{[1-G(e)]+(k-1)(e-c)g(p_s)\}$$
$$-\frac{\sum_{i=1}^{n}\left\{\frac{\partial Q_i}{}[1-F_i(Q_i)]\right\}\sum_{i=1}^{n}\left(Q_i+r\frac{\partial Q_i}{\partial r}\right)}{\sum_{i=1}^{n}\left\{\frac{\partial Q_i}{\partial r}[1-F_i(Q_i)]\right\}}=0 \tag{12.22}$$

Combining (12.8, 12.21, and 12.22) can solve r and e, and $E\prod_p$ can be obtained from formula (12.11).

If $E\prod_p > [E(p_s)-c]kM$,, then r and $e$are optimal solutions; On the contrary, $E\prod_p > [E(p_s)-c]kM$ then the r and e obtained are not the optimal solutions, here solving r and e needs simultaneous equations:

$$\begin{cases}\dfrac{\partial E\prod_p}{\partial e}=\dfrac{\partial E\prod_p}{\partial r}[1-G(e)]\\ r=\displaystyle\int_e^{\infty}(p_s-e)g(p_s)dp_s\end{cases} \tag{12.23}$$

12.4 Example

A manufacturing grid has a number of resource-based node enterprises. Investigate the option contract transaction among a certain resource supply-side p and its corresponding five resource demand-sides u_1, u_2, u_3, u_4, u_5 in a certain period. Assume the spot price of the manufacturing resource p_s follows uniform distribution of [20, 40], c = 20, M = 5000, k = 0.5, and the other relevant parameters as follows: (Table 12.1)

(1) As the necessary condition for any demand-side to accept the option contract is $r\le\int_e^{\infty}(p_s-e)g(p_s)dp_s$, so substitute the values of the relevant parameters, therefore, the values of r and e correspond to the values of the curve below in Fig. 12.1.

(2) Get the optimal solutions of r and e of the option contract. Take the values of relevant parameters into the equation (12.8), there are:

Table 12.1 Parameters' values of the resource demand-sides

Parameters	p_i	a_i	b_i	D_i	a_iD_i
u_1	50	1	1000	[0,1000]	[0,1000]
u_2	100	2	500	[0,500]	[0,1000]
u_3	180	4	250	[0,250]	[0,1000]
u_4	240	5	200	[0,200]	[0,1000]
u_5	420	10	100	[0,100]	[0,1000]

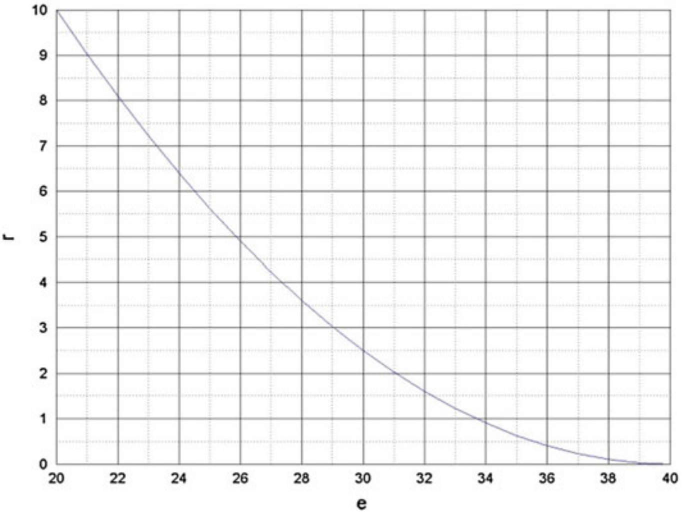

Fig. 12.1 Feasible domain of the option contract parameters

$$Q_1 = Q_2 = Q_3 = Q_4 = Q_5 = 1000 - \frac{40000r}{(e-40)^2} \tag{12.24}$$

Therefore,

$$Q = \sum_{i=1}^{5} Q_i = 5000 - \frac{200000r}{(e-40)^2} \tag{12.25}$$

$$\begin{aligned} \frac{\partial Q_1}{\partial r} = \frac{\partial Q_2}{\partial r} = \frac{\partial Q_3}{\partial r} = \frac{\partial Q_4}{\partial r} = \frac{\partial Q_5}{\partial r} = -\frac{40000}{(e-40)^2}, \\ \frac{\partial Q_1}{\partial e} = \frac{\partial Q_2}{\partial e} = \frac{\partial Q_3}{\partial e} = \frac{\partial Q_4}{\partial e} = \frac{\partial Q_5}{\partial e} = \frac{80000r}{(e-40)^3} \end{aligned} \tag{12.26}$$

Take (12.24, 12.26 into 12.21), and simplify:

$$r = \frac{(e-40)^3}{20(e-80)} \tag{12.27}$$

Take (12.24, 12.26 into 12.22), and simplify:

$$r^2 = \frac{(e-40)^4(3e-100)}{1600(e-100)} \tag{12.28}$$

Combine (12.27) and (12.28), there is: $\begin{cases} r = 1.4 \\ e = 28.8 \end{cases}$, and $E\prod_p \approx 30670 > 25000 = [E(p_s) - c]kM$, so $\begin{cases} r = 1.4 \\ e = 28.8 \end{cases}$ is the optimal solution, namely the reservation price should be 1.4 and the execution price should be 28.8. In this case, the total optimal contract purchasing quantity is $Q = 2770$, the expected profit of the supply-side is $E\prod_p = 30670$, and the expected profits of the five demand-sides are:

$$E\prod_{u_1} = 10480,\ E\prod_{u_2} = 10480,\ E\prod_{u_3} = 7980,$$
$$E\prod_{u_4} = 9840,\ E\prod_{u_5} = 6840$$

Investigate how the expected profit of the supply-side changes with r and e. Simplify Eq. (12.11), there is:

$$E\prod_p = \frac{50000(80-e)}{(e-40)^3} r^2 + 5000r - \frac{125}{4}(3e-80)(e-40) + 25000$$

Simulate in Matlab to see the changes of $E\prod_p$ when r continuously changes on the closed interval [0,3] and e takes different discrete values $(25, 27, 28.8, 30, 32)$, and the simulation result shows in the Fig. 12.2 above.

Figure 12.2 reflects the changes of expected profits of the supply-side ($E\prod_p$) in different values of r and e. It can be seen from the figure that $E\prod_p$ is at its highest point when $r = 1.4$, $e = 28.8$, here the value of the corresponding vertical axis is 30670, which is consistent with the previously obtained optimal solution $\begin{cases} r = 1.4 \\ e = 28.8 \end{cases}$, verifying the validity of the model's calculation.

(3) Examine the superiority of the option contract. In the case of non-existent option contract, that is all the resources are only traded in the spot market, combine $E(p_s) = 30$ and $E\prod_{u_i} = p_i E(D_i) - E(p_s)E(a_i D_i)$, there are:

(1) The expected profit of the resource supply-side is $E\prod_p = [E(p_s) - c]kM = 25000$;
(2) The expected profits of the five demand-sides are:

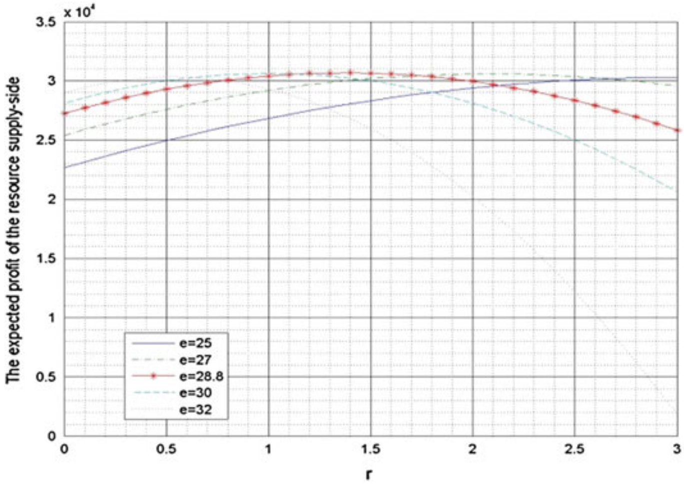

Fig. 12.2 Changes of $E\prod_{p}$in different values of (r, e)

$$E\prod_{u_1} = 10000,\ E\prod_{u_2} = 10000,\ E\prod_{u_3} = 7500,$$
$$E\prod_{u_4} = 9000,\ E\prod_{u_5} = 6000.$$

Compared with (2), the expected profits of all the sides of supply and demand have declined. Therefore, the existence of the option contract will distract the risks of the resource supply and demand sides, and enhance the flexibility of purchasing and using the resources and help to improve the overall efficiency of the grid environment, which has certain advantages in the grid environment.

12.5 Conclusions

The main conclusions in this paper have been summarized as follows:

(1) The dynamic feature of grid environment, the strict timing of manufacturing grid resource transaction and the importance of reservation mechanism under the grid environment make the option contract model feasible in the grid economic environment.
(2) The research on manufacturing grid resource pricing based on the option contract, is actually solving the two parameters of the option contract. These two parameters are from the game among all the sides of supply and demand in the objective of profits maximization, which mainly due to the demand of the manufacturing grid resource and the spot price. The spot price first directly affects whether the demand-sides will use the option contract to purchase and use the resource, then together with the market demand to determine the

contract purchasing and execution quantities, and thus indirectly affect the decision-making process of the contract parameters for the supply-side.

(3) The example shows that the expected profits of all the sides of supply and demand are higher in the existence of the option contract than that of non-existence, indicating that the option contract transaction will help to improve the overall effectiveness of the grid environment, and on this basis, the pricing strategy has certain superiority.

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Chapter 13
An Empirical Research on Coordination Degree of Industrial Economy–Ecology System Evolution in China

Yu-lin Zhao and Cui-hong Ye

Abstract An empirical analysis on coordination state of industrial economy-ecology system in China is given based on index system construction, using the coordination measurement model with respect to composite system. Results show that coordination degree of industrial system in China is of increasing trend from 1996 to 2010 on the whole, that is contributed greatly by steady promotion of order degree of industrial economy, but is yet of low level, that is mainly due to the fluctuation of order degree of industrial ecology. Structure upgrade which not only refers to high servicisation level, but especially high-tech and high processing degree, and technology innovation the key of which is to make traditional one and eco-innovation an organic whole to realize economic benefit and meanwhile ecological benefit, are the core of coordinated evolution of industrial economy-ecology system.

Keywords Coordination degree · Industrial ecology · Industrial economy · Industrial system · Order degree

13.1 Introduction

With the acceleration of industrialization progress, the contradiction between economic development and environmental constraints has become increasingly prominent. How to re solve this contradiction has become a major issue of great

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concern by governments and academia. Industrial ecology and circular economy put forward new ideas to solve the problem.

China's economy has sustained fast growth since the reform and opening up. But the fact of the first rank of carbon emissions in the world with 1/3 of total GDP of America shows that the problem between economic growth and environmental constraints in China is extremely urgent. However industrial ecology is often regarded only as a means of environmental protection by governments and research scholars in China (Deng and Chen 2006), clearly that is inconsistent with a developing country, because the economic strength has not yet reached to the level which can manage the environment at the expense of economic benefit with a wide range.

Practice has proved that traditional industrialization only seeking economic growth has accelerated resource depletion and environmental pollution, and programs which only emphasize ecological protection can not effectively solve the contradiction. In the paper industrial economy and industrial ecology are incorporated into industrial system from the perspective of systematics. On the base of index system construction considering the target of industrial system evolution including both economic benefit and ecological benefit, an empirical analysis on coordination state of industrial economy-ecology system in China is given, using the coordination measurement model with respect to composite system.

13.2 Definition of Coordination Degree of Industrial Economy-Ecology System Evolution

Industrial economy-ecology system, which can be called industrial system for short, is the complex constituted by various industries, and characterized jointly by economic and ecological variables. In general, industrial economy studies inter-industry relationship only from an economic point of view, while industrial ecology usually only from an ecological perspective. However the relationship among industries is discussed from the perspective of the unity of industrial economy and industrial ecology in the paper. The state of industrial economy and industrial ecology is of constant transition, among the disorder, low order and high order, to form specific structure and function of industrial system, under the action of self-organization within the system and hetero-organization from the outside. The degree of harmonious coexistence of industrial economy and industrial ecology with each other during the evolution process is known as the coordination degree of industrial economy-ecology system evolution.

13.3 Construction of Coordination Measurement Model of Industrial Economy-Ecology System Evolution

13.3.1 Coordination Measurement Model of Industrial Economy-Ecology Composite System

The coordination measurement model of composite system proposed by Meng and Han (2000) has been widely used in studies (Tao and Qi 2009; Tao et al. 2007; Bi and Sun 2010), many of which are for industrial organization, industrial innovation and industrial system. Learning from the principle of the coordination measurement model of composite system, the paper firstly figures up order degree of industrial economy and industrial ecology based on the calculation of order degree of order-parameter indicators, whose contribution to subsystems is taken into account comprehensively, and then coordination degree of industrial system is obtained by the integration of order degree of subsystems.

Let the subsystem of industrial economy-ecology composite system be S_j, $j \in [1, 2]$, and order-parameter indicators of industrial subsystem in the evolution process be $e_j = (e_{j1}, e_{j2}, \ldots, e_{jm})$, $m \geq 1$, $\beta_{ji} \leq e_{ji} \leq \alpha_{ji}$, $i \in [1, m]$. Suppose that the greater the value of e_{j1}, e_{j2}, …, e_{jk} ($j = 1, 2$), the higher order degree of the system, and the smaller the value, the lower order degree of the system; the greater the value of $e_{j(k+1)}$, …, e_{jm} ($j = 1, 2$), the lower order degree of the system, and vice versa.

Then order degree of e_{ji} in S_j is as follows:

$$u_j(e_{ji}) = \begin{cases} (e_{ji} - \beta_{ji})/(\alpha_{ji} - \beta_{ji}), i \in [1, k] \\ (\alpha_{ji} - e_{ji})/(\alpha_{ji} - \beta_{ji}), i \in [k+1, m] \end{cases} \tag{13.1}$$

in which α_{ji} and β_{ji} are respectively the upper and lower limit value of e_{ji} in S_j. It can be seen from formula (13.1) that $u_j(e_{ji}) \in [0,1]$, and the larger its value, the greater the contribution of e_{ji} to the ordering of S_j. Total contribution of e_{ji} to order degree of S_j is attained by the integration of $u_j(e_{ji})$. Correlation matrix weighted method can objectively reflect actual status of order-parameter indicator in the subsystem, using correlation coefficients among indicators to represent the importance of indicators in the subsystem. Therefore it is used to determine the weight of e_{ji} in S_j, and then order degree of S_j is got by weighed summation.

Suppose that correlation matrix of S_j is:

$$R_j = \begin{pmatrix} r_{11} & \ldots & r_{1m} \\ \ldots & \ldots & \ldots \\ r_{m1} & \ldots & r_{mm} \end{pmatrix}, \text{in which } r_{ii} = 1(i = 1, 2, \ldots, m).$$

Let $R_{ij} = \sum_{q=1}^{m} |r_{iq}| - 1(i = 1, 2, \ldots, m)$, Then R_{ij} represents whole influence of e_{ji} to all the other indicators in S_j. The larger the value of R_{ij}, the greater the influence of e_{ji} in S_j, so the larger the weight should be. Therefore, the weight of corresponding indicator is as follows:

$$\omega_{ij} = \frac{R_{ij}}{\sum R_{ij}}.$$

Order degree of S_j:

$$u_j(S_j) = \sum_{i=1}^{m} \omega_{ij} u_j(e_{ji}). \tag{13.2}$$

Known by formula (13.2), $u_j(S_j) \in [0,1]$. The greater the value of $u_j(S_j)$, the higher order degree of S_j; and vice versa. Let $u_j^{t_0}(S_j)$ be order degree of S_j at the initial time t_0, and $u_j^t(S_j)$ be order degree at the time t. Define coordination degree of the evolution of industrial system:

$$cd = \theta \sqrt{\left| \prod_{j=1}^{2} \left[u_j^t(S_j) - u_j^{t_0}(S_j) \right] \right|},$$

in which

$$\theta = \frac{\min\limits_j \left[u_j^t(S_j) - u_j^{t_0}(S_j) \right]}{\left| \min\limits_j \left[u_j^t(S_j) - u_j^{t_0}(S_j) \right] \right|}. \tag{13.3}$$

Formula (13.3) shows that $cd \in [-1,1]$. The larger of cd indicates the higher of coordination degree of industrial system; and vice versa. If order degree of one subsystem is larger, while the other is smaller or decrease, coordination degree of industrial system will be not high.

13.3.2 Index System of Coordination Degree of Industrial Economy-Ecology System

13.3.2.1 Order-Parameter of Industrial Economy

(1) Quantity of growth: As a dynamic evolutive economic body, economic growth is the direct goal of industrial system evolution. Traditional economic growth refers to constantly increasing process of social material wealth, which presents itself as the increase of gross domestic product (GDP) (Wei and Hou

2007), which is usually used to measure economic growth by scholars. Therefore, GDP is used to measure the quantity of growth in the paper.

(2) Quality of growth: Economic growth not only includes the growth of quantity, but also the promotion of quality. For the comprehensiveness, total factor productivity (TFP) is significant symbol of the promotion of economic growth quality and technology progress (Wu and Li 2006). World Bank and OECD often use the change of TFP to observe the quality of economic growth (Zheng 2007). Thus TFP is used for measuring the quality of growth of industrial economy.

(3) Structure of growth: Economic growth of high quality inevitably accompanies with industrial structure upgrade, which is often measured by proportionate relationship among three industries, the industry and the manufacture (Huang and Chen 2007; Shi 1994; Lin and Jiang 2009) in much empirical analysis. High servicisation level, high processing degree, and high technology degree, which respectively are expressed by the rate of value added of tertiary industry in GDP, total output value of the manufacture in the industry and total output value of hi-tech industry in the manufacture, are thought as main representations for measuring the upgrade of industrial structure.

13.3.2.2 Order-Parameter of Industrial Ecology

(1) Ecological quantity: Ultimate goal of industrial ecology is the minimization of energy consumption and waste discharge from industrial activity to natural system. Therefore, total amount of energy consumption and waste discharge which is mainly the three wastes of the industry, are intuitive indicators of industrial ecology.

(2) Eco-efficiency: As an important dimension of the evaluation of industrial ecology, eco-efficiency is used for the description of the relationship of economic growth and the impact on eco-environment (Huppes and Ishilcawa 2007). Unit GDP energy consumption and three industrial waste discharge, are used for measuring eco-efficiency.

To be point out, the selected indicators of ecological quantity and eco-efficiency are negative, that is the greater the indicator value, the lower ecological benefit.

(3) Eco-innovation: As a means of achieving industrial ecology, eco-innovation is difficult to measure due to the lack of regular statistics. The output of eco-innovation can be expressed by the property of energy conservation or environmental protection of products. The application quantity of environmental patent, which can be expressed by the inventive patent related to energy conservation or environmental protection, is often used to represent eco-innovation in seldom empirical analysis (Brunne Rmeier and Cohen 2003; De vries and Withagen 2005). Another key objective of eco-innovation is to achieve material cycle among industries by the reutilization of wastes, which

is the essence of industrial ecology and the key of realizing coordinated evolution of industrial system. Hence, comprehensive utilization level of wastes, which is measured by the rate of comprehensive utilization of industrial solid waste and output value of products from comprehensive utilization of the three wastes in the industry, is innovatively used to measure the eco-innovation.

13.4 Empirical Analysis on Coordination Degree of Industrial Economy-Ecology System Evolution in China

13.4.1 Data

Considering the accessibility of observed value of indicators, most of which is attained from *China Statistical Yearbook*, *China Environment Statistical Yearbook*, *China Energy Statistical Yearbook*, *China Statistics Yearbook on high Technology Industry*, *China Industrial Economy Statistical Yearbook* over the years except that the application quantity of environmental patent is got from Chinese patent database, the sample period is selected from the year of 1995 to 2010. TFP is gained by non-parameter Malmquist index method using the date of GDP, capital and labor input from the year of 1994 to 2010. Perpetual inventory method is used to get the capital input, in which fixed capital stock in 1994 is taken from the estimate result of Research group on China's economic growth and macroeconomic stability (Research group on China's economic growth and macroeconomic stability (CASS) 2010), and total amount of fixed capital formation, which is dealt with price index of fixed assets invested, the year of 1994 as the base period, is used as the amount of newly increased fixed assets invested, and the rate of depreciation is 5 %. The value of GDP in the order-parameter of quantity of growth, eco-efficiency, and in the calculation of TFP are all adjusted with constant price method using the year of 1994 as the base period.

13.4.2 Results

13.4.2.1 The Weight of Order-Parameter Indicator of Industrial Economy-Ecology System

Using the maximum and minimum value during the year of 1995–2010 respectively as the upper limit and lower limit of each indicator, order degree of order-

Table 13.1 Index system and the weight of order-parameter indicator of industrial system

Subsystem	Order-parameter	Indicator	Weight
Industrial economy	Quantity of growth	GDP (hundred million yuan)	0.18
	Quality of growth	TFP (100 %)	0.25
	Structure of growth	Total hi-tech industry output value/total manufacture output value (100 %)	0.22
		Value added of tertiary industry/GDP (100 %)	0.27
		Total manufacture output value/total industrial output value (100 %)	0.08
Industrial ecology	Ecological quantity	Total energy consumption (tons standard coal)	0.10
		Industrial solid waste discharge (ton)	0.08
		Industrial exhaust emission (hundred million standard stere)	0.10
		Industrial wastewater discharge (tons)	0.09
	Eco-efficiency	Total energy consumption/GDP (ton standard coal/ten thousand yuan)	0.07
		Industrial wastewater discharge/GDP (ton/ten thousand yuan)	0.09
		Industrial exhaust emission/GDP (standard stere/ten thousand yuan)	0.09
		Industrial solid waste discharge/GDP (kilogram/ten thousand yuan)	0.09
	Eco-innovation	Application quantity of environmental patent (term)	0.10
		Rate of comprehensive utilization of industrial solid waste (100 %)	0.10
		Output value of products from comprehensive utilization of the three wastes/total industrial output value (100 %)	0.08

parameter indicator is calculated using formula (13.1). Then weights of indicators are obtained according to correlation matrix weighted method (Table 13.1).

In industrial economy subsystem, the weight of growth quality and high servicisation level of the structure is higher, and high processing degree of the structure is the lowest. Comparatively, weights of indicators in industrial ecology subsystem have little difference with each other.

13.4.2.2 Order Degree of the Subsystem of Industrial Economy-Ecology System

Order degree of order-parameter indicator is summed by the weight of each indicator to get order degree of industrial subsystems. The rate of weighted summation of indicators for each order-parameter in the order degree of the subsystem is made as the quotient contribution of the order-parameter to the subsystem.

As is shown in Table 13.2, order degree of industrial economy in China is showing a steady upward trend, and it increased by about 11 times during the year of 1995–2010. Quotient contribution of the quantity of growth is of steady and slightly increasing trend on the whole, but the quality of growth is of decreasing trend. The structure of growth has the largest share of the contribution, but also shows a downward trend.

Table 13.2 Order degree of industrial economy and quotient contribution of order-parameter during 1995–2010

	Order degree of industrial economy	Quotient contribution		
		Quantity of growth	Quality of growth	Structure of growth
1995	0.0692	0	0	1
1996	0.1219	0.05	0.68	0.27
1997	0.2745	0.04	0.45	0.51
1998	0.4095	0.04	0.35	0.61
1999	0.497	0.05	0.32	0.63
2000	0.5777	0.05	0.30	0.65
2001	0.6571	0.06	0.28	0.66
2002	0.731	0.06	0.27	0.67
2003	0.771	0.07	0.26	0.66
2004	0.7248	0.09	0.28	0.63
2005	0.7516	0.11	0.29	0.61
2006	0.7849	0.13	0.29	0.58
2007	0.8279	0.15	0.30	0.55
2008	0.7631	0.18	0.28	0.54
2009	0.8036	0.20	0.24	0.56
2010	0.8239	0.22	0.26	0.52

Table 13.3 Order degree of industrial ecology and quotient contribution of order-parameter during 1995–2010

	Order degree of industrial economy	Quotient contribution		
		Ecological quantity	Eco-efficiency	Eco-innovation
1995	0.4827	0.61	0.22	0.16
1996	0.5522	0.59	0.29	0.12
1997	0.6103	0.58	0.35	0.07
1998	0.5125	0.52	0.32	0.16
1999	0.6081	0.50	0.38	0.12
2000	0.6483	0.48	0.39	0.13
2001	0.6590	0.45	0.38	0.17
2002	0.6568	0.43	0.40	0.17
2003	0.6281	0.42	0.41	0.16
2004	0.5562	0.41	0.42	0.16
2005	0.5286	0.34	0.45	0.22
2006	0.5371	0.30	0.41	0.29
2007	0.5344	0.24	0.42	0.34
2008	0.5857	0.22	0.44	0.34
2009	0.6035	0.21	0.44	0.35
2010	0.5429	0.17	0.46	0.36

Table 13.3 shows that order degree of industrial ecology in China which only increases by 12 % during the year of 1995–2010, is relatively stable on the whole. Quotient contribution of ecological quantity shows an apparent decreasing trend, eco-efficiency and eco-innovation a slow upward trend in the fluctuations.

13.4.2.3 Coordination Degree of Industrial Economy-Ecology System

According to formula (13.3), coordination degree of industrial system in China during the year of 1996–2010 is calculated. Further the trend of order degree of subsystems and coordination degree of industrial system is mapped out (Fig. 13.1).

Coordination degree of industrial system the average annual growth rate of which is up to 9.41 %, is showing rising trend overall. Although coordination degree of industrial system in China is of upward trend, the average coordination degree during the period of 1996–2010 is only $0.23 > 0$. It indicates that industrial system in China is of the state of coordinated development as a whole, but its coordination degree is yet not high.

13.4.3 Result Analysis

(1) Coordination state of industrial system in China improves constantly in general, mainly due to stable performance of order degree of industrial economy,

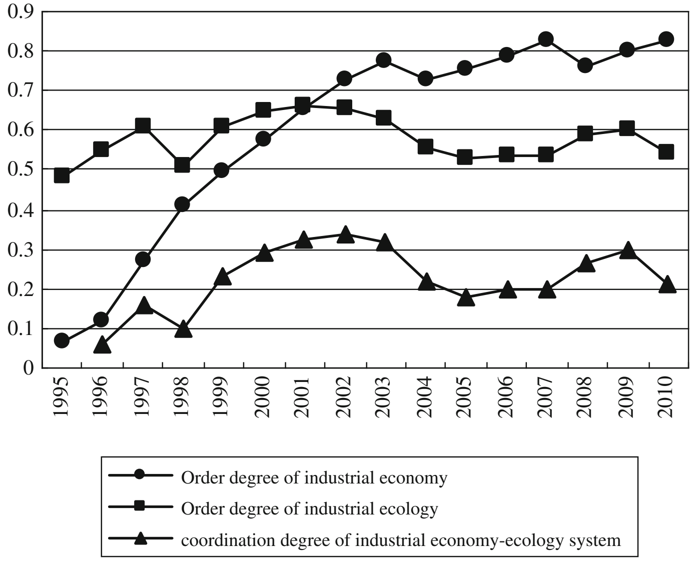

Fig. 13.1 Coordinated development trend of industrial system during 1995–2010 in China

while the enhancement of order degree of industrial ecology is smaller. It indicates that industrial economic growth is still the main content of industrial system in China as a developing country in the last decade. The growth is reflected not only the growth of quantity, but also the enhancement of quality, and the structure upgrade. Technological progress and servicisation upgrade of the structure have played a leading role in the evolution of industrial economy. However, order degree of industrial economy in China still has room for further improvement, especially through the promotion of high technology degree and processing degree of the structure, to enhance the position of products of China in the value chain of the world, and give high processing degree and high-tech degree of the structure full play to industrial economy.

(2) Industrial system in China is still in lower coordination state, mainly due to the constant fluctuation of order degree of industrial ecology. On the whole the state of ordering of industry ecology is of much improvement, mainly presenting itself as the promotion of eco-efficiency and eco-innovation. Energy consumption, industrial exhaust emissions and eco-innovation play key roles in the evolution of industrial ecology. Even though the enhancement trend of eco-innovation of China is more obvious over the latest years, that makes the efficiency of energy use and much of waste discharge be enhanced, total energy consumption and much of industrial waste discharges are still on the rise, that is the main source of not obvious enhancement of order degree of industrial ecology, except that solid waste discharge falls with the enhancement of comprehensive utilization level of industrial solid waste.

(3) Technological innovation is the essential power to drive the coordinated evolution of industrial system. From the importance of technological progress in industrial economy, and eco-innovation in industrial ecology, technology innovation is the key to promote the continuous optimization of coordinated state of industrial system. Especially the combination of traditional technological innovation and eco-innovation should be reinforced to promote the productivity, the upgrade of the structure and economic development, meanwhile reduce resource consumption and environmental pollution.

13.5 Conclusion

Industrial economy-ecology system is the complex constituted by various industries, and characterized jointly by economic and ecological variables. On the base of index system construction, an empirical analysis on coordination state of industrial system during the year of 1995–2010 in China is given, using the coordination measurement model. Results show that coordination degree of industrial system in China is of the promotion overall over the last decade, but is yet of low level. As a developing country, economic growth is still main content of industrial system in China, and the enhancement of order degree of industrial ecology is smaller. Structure upgrade and technological innovation are the core of coordinated development of industrial system.

Governments at all levels need to promote not only servicisation upgrade of the structure, but also high-tech degree and high processing degree of the structure when accelerating industrial structure restructuring, to increase added value of products, give structure upgrade full play to enhance economic growth; on the other hand, governments should take eco-innovative ideas into traditional technological innovation, increase innovation inputs further, promote innovation efficiency, to improve energy efficiency and environmental efficiency, realize the reutilization of wastes, ultimately achieve economic benefit and generate ecological benefit at the same time.

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Chapter 14
Analysis of Two Kinds of Technology in the Production System

Quan-qing Li and Ming Li

Abstract The production system includes the professional engineering technology and industrial engineering technology. Someone ever put the two technologies compared to two ears of a bucket. This paper considers that using bucket model to describe the relationship of the two kinds of technology is not accurate. This paper puts forward the board truck model to describe the relationship between them, and considers they are the relationship of parking floor and side boards in a board truck. This paper analyzes these characteristics of industrial engineering technology relative to the professional engineering technology, such as seeking optimization, non-independence, time hysteresis, function hysteresis and matching function, and so on. It also analyzes the problems that are generated by these characteristics in the aspects of the spread and popularity of industrial engineering, and puts forward the suggestions that develop the industrial engineering technology and theory.

Keywords Production system · Industrial engineering technology · Professional engineering technology · Board truck model

14.1 Introduction

Since Taylor, industrial engineering father, published "Scientific management Principle" in 1911, the industrial engineering already has had 100 years history (Wei et al. 2000). For 100 years, the industrial engineering development is rapid and has become the popular specialty in a lot of fields. Joseph Juran, American

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quality expert ever said proudly that the United States was able to win the victory of the Second World War, it relied on the industrial engineering (Liu and Lu 2006). In Japan, it combines the Confucian culture and the thinking of industrial engineering, the lean thinking came into being, and created a new manufacturing mode, the world is from the mass production age into the multi-product and change demand production age (Chen 2011).

But on the other hand, industrial engineering theory research and the popularization and application are also unsatisfactory (Guo 2004), its development and the popularization speed cannot achieve the hope of experts and enterprises far away. Therefore, to clarify the various technologies in the production system, including manufacturing automation technology, numerical control technology, management technology, to study the relationship among these technologies is undoubtedly quite necessary.

14.2 Two Kinds of Technology in the Production System

14.2.1 Activities of the Production System

The production system is the integrated system that investment converts into outputs, or the inputs convert into outputs, to realize input, conversion and output compose (Ding et al. 2007). It is shown in Fig. 14.1.

In the activities of production system, "conversion" refers to the production process; "investment" refers to the various factors of production that need in production process, "delivers" refers to the products that have produced, of course, also including these wastes, such as wastewater, iron filings, and so on.

For example, in the machinery manufacturing industry, what investment is manufacture resources of workshop, equipment, raw material, personnel, electrical energy, capital and so on, the conversion refers to the technology activities of processing, inspection, heat treatment, assembly and so on, what delivers are the machinery products. In the field of highway and traffic transportation, what investment is the resource of vehicle, fuel oil, highroad, drivers, and so on, the conversion mainly refers to the vehicles driving, but delivers mainly refers to the passenger or the goods have arrived at the destination.

Fig. 14.1 Activities of the production system

14.2.2 Two Kinds of Technology in the Production System

In Fig. 14.1, "conversion" is the most important problem which the people pay attention. It is the key to decide the system benefits. In achieving the conversion, at least two kinds of technology play their role. One is the technology to realize physical and chemical change, which makes the input resources has had the change in the shape, quality, material, displacement, and even function and so on. It is the necessary condition that the system has the conversion function. The other is the technology to realize the resources combination, and distribution, which makes the system convert with high efficient, high quality and low cost. The first technology is called the professional engineering technology; the second technology is called the industrial engineering technology. In the mechanical manufacturing, the first technology pay attention to the production process; the second technology pay attention to the production management.

Using two examples illustrate the two kinds of technology. In the mechanical manufacturing industry, such as machine tools, cutting tool design, cutting parameters choice, machine tools operation and operators training, etc., must use the professional technology; in a workshop, a production line, the equipments layout, production plan establishment, materials distribution, production site control and so on, have to use industrial engineering technology. In highway and traffic transportation, vehicle design and driving, highway construction and maintenance and so on, use the professional technology; but vehicle dispatching, bus station or freight yard layout and so on, use the industrial engineering technology. For any system, improving efficiency and reducing cost are its aspiring objective. In the machinery manufacturing industry, to achieve this objective, the first technology, that is the professional technology, is mainly to consider based on processing, requirements and object, from these aspect of machine tools selection, cutting tools design, cutting parameters determined, processing craft determined and so on, and the second technology, that is industry engineering technology is mainly to consider from the aspects of production line balancing, reducing the number of WIP, determining the time that the equipment begins work or completes work, material supply and flow. In the highway and traffic transportation, seeking the objective to raise the efficiency, reduce the cost, the professional technology is mainly to consider from the aspects of the scientific carrying passengers or loading cargo, reducing fuel oil consumption, reducing tyre wear, increasing pure running time and so on, but the industrial engineering technology is mainly to consider from the aspects of the scientific choice running line, the goods direct sending and direct arriving, through transport.

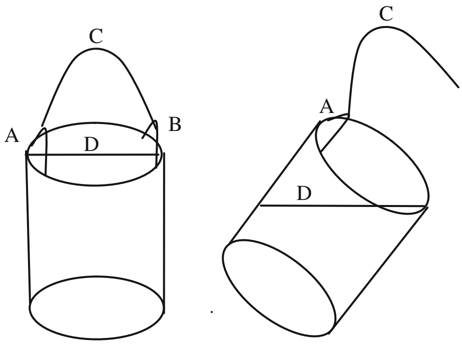

Fig. 14.2 Bucket model of the two kinds of technology relationship

14.3 Relationship of the Two Kinds of Technology in the Production System

14.3.1 Bucket Model

The two kinds of technology in the system should be interdependence, support each other, the two engineering technologies should be matching. Someone using "bucket model" analogies the relationship of the two technologies (Qi and Huo 2005), it is shown in Fig. 14.2. The system efficiency may be compared to the water in the bucket; the objective is to make the water in the bucket is the more, the better. The professional engineering technology is compared to an ear of the bucket, and industrial engineering should be another ear. If lacking the industrial engineering, the bucket only has an ear; even if put in a lot of effort at technology, you can only bring up half a bucket of water. If want to bring up full of water, you must make the best of the two ears of professional technology and industrial engineering technology.

14.3.2 Board Truck Model

Bucket model illustrates the importance of industrial engineering technology in the production system, it is helpful to vividly understand the role of the industrial engineering technology; and this is undoubtedly very useful for understanding the industrial engineering technology. But the bucket model cannot deeply describe the relationship between industrial engineering and professional engineering technology, in particular, after the application of industrial engineering has gone through the original glorious, now it has entered a relative slowly development stage, it is the unsatisfactory stage, but the bucket model cannot explain this phenomenon.

This paper considers, it is more suitable to describe the relationship of professional engineering technology and industrial engineering technology by means

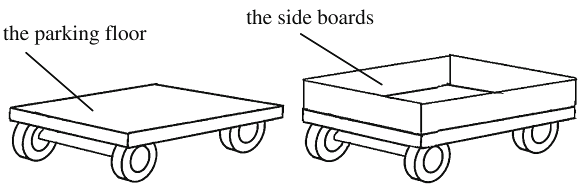

Fig. 14.3 Bucket model of the two kinds of technology relationship

of board truck model. As shown in Fig. 14.3, the production system can be expressed a board truck, the professional engineering technology is the parking floor of the board truck, industrial engineering technology is the side boards on the parking floor, the system efficiency is the amount of goods that is loaded by the board truck. Without industrial engineering technology, it likes the board truck only has parking floor, without side boards, although it can load goods, but not much, which indicates that no industrial engineering technology, production system is not possible to obtain good economic benefits. Only using the appropriate side boards, the board truck can load more goods; the production system can obtain more economic benefits.

14.3.3 Relationship Between the Two Kinds of Technology

The board truck model can vividly explain the relationship of the professional engineering technology and industrial engineering technology.

(1) The parking floor is the necessary condition that a board truck loads goods.

As for a board truck, no the parking floor, that does not have board truck, so the parking floor is the necessary condition to form board truck. That is to say, the professional engineering technology is the necessary condition of the production system existence and running, it has solved the problem of "that is possible", without it; the system is unable to run, so it cannot be neglected. As for a board truck, the side boards not are the necessary condition, without side boards, the board truck can load goods yet, the importance of the side boards is they can make the board truck load much goods. That is, the industrial engineering technology is not the necessary condition of the production system running, without the industrial engineering technology, the system is also able to run, but it is impossible to obtain good benefits, Not aimed at the specific production field and system, broadly to talk about the industrial engineering technology is no significance, the industrial engineering technology can not break away from the professional engineering technology to exist alone, what it solves is the problem of "nice or no", it is the sufficient and necessary condition that the system runs with high efficiency, high quality and low cost. This characteristic of industrial engineering technology is called "seeking optimization characteristic".

(2) The parking floor is the premise of the side boards' existence.

In the board truck model, the side boards cannot exist alone. Without parking floor, talking about the side boards is meaningless. Similarly, not aimed at the specific production field and system, broadly to talk about the industrial engineering technology is also no significance, the industrial engineering technology can not break away from the professional engineering technology to exist alone, industrial engineering is attached to the professional engineering technology. This is the "non-independent characteristic" of industrial engineering technology.

(3) The parking floor is the problem to be first considered when manufacture a board truck.

When design and manufacture a board truck, one of the problems to be first considered is the parking floor, and then considers the side boards of the board truck, that is, for the side boards relative to the parking floor, there is a lag period. As for production system, relative to the professional engineering technology, industrial engineering technology has a lag period yet, especially in terms of a simple production system. In designing and manufacturing production system, the first concern is these problems of professional engineering technology, such as machine tool, cutting tool, fixture, craft, material transportation and storage, then it is possible to focus on the industrial engineering problems of production plan and material flow, and so on. This is the "time hysteresis" of industrial engineering technology.

(4) In using board truck, the parking floor generate benefits firstly.

When using a board truck, from the standpoint of generating system benefits, the parking floor produces effect firstly: the goods loaded into a broad truck is carried by the parking floor firstly; only when the goods on the parking floor to a certain extent, the side boards take effect yet. Similarly, in a production system, first to produce economic benefits is the professional engineering technology. For example, using professional engineering technology to reduce waste, the cost to be reduced is showed up immediately; and using the industrial engineering technology to reduce the quantity of WIP, it can reduce the cost much more, but the effect can be appeared only after the system runs a period of time, this is the "benefit hysteresis" of industrial engineering technology.

(5) Side boards must match with parking floor.

For different vehicles, the requirements to parking floor is not the same, it must be designed according to the types of carrying the goods, for example, the parking floor to carry liquid goods must have good tightness. The side boards must naturally match with the goods, which is to match with the parking floor. In production system, the professional engineering technology of manufacturing machinery products and manufacturing of electronic products is not the same, similarly, the industrial engineering technology that is suitable for machinery products and electronic products is also not the same; even for mechanical manufacturing enterprises, because of the different products, it will apply different industrial engineering technology. Different countries, different regions, when produce the same products or similar products, it can apply the exactly same professional engineering technology, but industrial engineering technology cannot, although industrial engineering's theories have the universality, but not all industrial engineering methods have the universality. The industrial engineering almost is the technology to solve the question by "one-to-one", it must be integrated with oneself enterprise culture and even region to apply flexibly (Li and Li 2011), this is the matching characteristic of industrial engineering technology.

14.4 Difficulties and Countermeasures of Industrial Engineering Technology Development

14.4.1 Technology Reasons Analysis that Industrial Engineering can not be Developed Rapidly

For over 100 years, the application of industrial engineering is unsatisfactory; this has a variety of complex reasons, such as market, culture, ideas, technology and so on. The board truck can explain the reasons pertinent to "technology" aspect.

Relative to the professional engineering technology, these characteristics of seeking optimization, non-independence, hysteresis of industrial engineering technology make many entrepreneurs did not pay enough attention to implement industrial engineering technology. Many entrepreneurs take note of the professional engineering technology merely, satisfy in the normal running of production system, satisfy in "doable" this basic objective to realize, do not aspire after "good" this higher objective, without the desire of "seeking optimization characteristic", for implementing the industrial engineering technology has not the sense of urgency. In particular, below the big setting of global economic integration, the market is increasingly important, the product life cycle is increasingly short, many entrepreneurs focus on using products to open up market, pay attention to the professional engineering technology to create new products, so this situation will be appeared: for a certain product, its life cycle is too short, the lag period of industrial engineering technology is not yet over (corresponding industrial engineering technology has not produced yet), this product has entered into the decline period, and the professional engineering technology that create the new product has draw attention, but the industrial engineering technology did not take into account, or even forgot.

The matching characteristic of the industrial engineering technology and the professional engineering technology, makes it must to research and create new industrial engineering technology after the new industrial engineering technology is applied and created, or when the industrial engineering technology is extended to the new application fields. But in many cases, this is a difficult job. Even in what aspects to apply industrial engineering technology, what industrial engineering technology can be used, all need to research seriously. Many enterprises that have great expectations to industrial engineering technology, because unable to find suitable industrial engineering technology, finally disappointed, and doubt industrial engineering, or even give up the efforts to apply industrial engineering.

14.4.2 Suggestions of Industrial Engineering Technology Development

It should widely popularize the basic knowledge and idea of industrial engineering. It should mainly give publicity to the "seeking optimization characteristic" of industrial engineering technology. The industrial engineering is one kind of idea for seeking "better", it does not satisfy the present situation, think that "there is always a better way" (Shun 2008). Satisfying present situation is the sworn enemy of industrial engineering.

The industrial engineering is produced in order to solve the management problems of production site of manufacturing industry; taking the efficiency as the objective, so the industrial engineering is called "efficiency engineering" (Li 2005). At present, the world has entered into a global economic integration times, the key points of researched by industrial engineering technology should be suitable for this change. In theory, it should study the new production mode (Li 2001). In technology, it should study the distribution method of the global resources optimization, in order to introduce new products better, faster and more economical.

The industrial engineering should speed up the research of technology and method. Along with the expansion of industrial engineering application range, the industrial engineering theory research relatively is not very backward, but the research of technology and method has lagged far behind the needs of enterprises. For enterprises, the technologies and methods are the most important. Only to innovate the technologies and methods which can be operated, it can shorten the "slow growing period" of industrial engineering development, speed up its spread and popularity.

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Chapter 15
ASP Based Resource Sharing Model for Networked Manufacturing

Guo-qing Wang and Xiao-li Lv

Abstract A distributed collaborative ASP model is presented in this paper. Then, the architecture for resource scheduling is introduced, and the business process of networked manufacturing resource scheduling based on this architecture is analyzed. Because of the difference between resource scheduling of networked manufacturing and resource scheduling of job shop, as well as the geographically distributed, dynamic and employed characteristic, the resource reservation time based scheduling method is proposed. Furthermore, the objective of resource scheduling is determined by synthesizing the factors of provider, client and administrator of system. We built the mathematical model of scheduling objective such as the due date of client, profit margin of resource and load balance from the applied point of view. Finally, the branch and bound algorithm is adopted to compute this model. The feasibility and practicability of the proposed method were verified by the development and preliminary application.

Keywords Distributed · Networked manufacturing · Resource sharing · Scheduling model

15.1 Introduction

Networked manufacturing shows two advanced manufacturing model as distributed cooperating model and ASP based model (Wang et al. 2002). Distributed collaborative model is a fully distributed method; the Virtual Organization is

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formed according to the requirement of client, and disappeared when the requirement is over. However, Application service provider (ASP) can be defined as the service provider who manages and delivers standard application functionality or associated service across a network to multiple customers (Wang et al. 2002). The traditional networked manufacturing ASP platform is based on central server and is a kind of one-for-more service model by Internet or intranet. These two models that support the networked manufacturing are huge manufacturing projects, so most researchers can only do a little job in some way.

Hao utilized intelligent software agent to realize a prototype system of product design engineering on FIPA-compliant platform, and verified the system by wheel and axle sample in the application of cooperative design (Hao et al. 2006; Shen and Ghenniwa 2003; Wang et al. 2003). Wang studied the distributed resource sharing from key technology and platform development. He analyzed cooperative manufacturing business process across enterprises, and then, proposed the Agent based manufacturing platform driven by flexible workflow technology (Shen and Hao 2004; Hao et al. 2005; Bellifemine et al. 2001; Poslad et al. 2000). Zhang studied on concurrent control mechanism and cooperative control rules in the product development supported by CSCW technology (Hao et al. 2005; Bellifemine et al. 2001). Dai discussed the key technology of ASP based networked manufacturing system from user management, Web Service based service integration and management to toll management system (Poslad et al. 2000; He et al. 2005; Zhang and Zhou 2004; Dai et al. 2005). Yan (Yan and Wu 2001; Li and Jiang 2000; Duffy and Salvendy 2000; Krishnan 1998) presented a heuristic scheduling method used in concurrent design process of products.

From above literature we can see that there is less research about distributed resource scheduling than centralized scheduling. And there is no effective method to instruct the implementation of networked manufacturing resource scheduling. However, the traditional networked manufacturing ASP platform is based on central server, so there are the problems of poor service ability and network bandwidth bottleneck. The implementation of distributed scheduling system is very difficult. Therefore, an ASP based model incorporating distributed and centralized mechanism is presented, and the resource scheduling of this model is analyzed in detail in this paper.

15.2 ASP Based Model of Networked Manufacturing Resource Scheduling

15.2.1 Distributed Service Model of ASP Platform

The innovation of distributed ASP service model is that Client can login the system to access more ASP nodes through a single Web portal. These ASP nodes have different manufacturing service ability locating in different regions. Each

ASP node can respond all kinds of manufacturing requests because of owning self-governed server and manufacturing resource management system. To query the optimal resource, this node is in charge of forwarding it to other nodes. In this way, one client can visit multi-ASP nodes over the Internet.

It is the key of ASP platform system that How to allocate the available manufacturing resource quickly and effectively for manufacturing request of ASP platform system. Furthermore, this allocation should make network load balanced as finishing the task of client. The resource cooperating allocating of networked manufacturing ASP platform can be regarded as mapping from application to resource. So when the task is disassembled into more sub tasks, we depict DAG (Directed acyclic graph) to denote it. In this paper, we use workflow based network graph to denote a manufacturing task. The node can be looked as activity of manufacturing task, and the connecting side is the time sequence between activities. In the resource scheduling of networked manufacturing, we not only consider the time sequence between activities, but also the constraint of resource reservation time. The ASP platform is shown in Fig. 15.1.

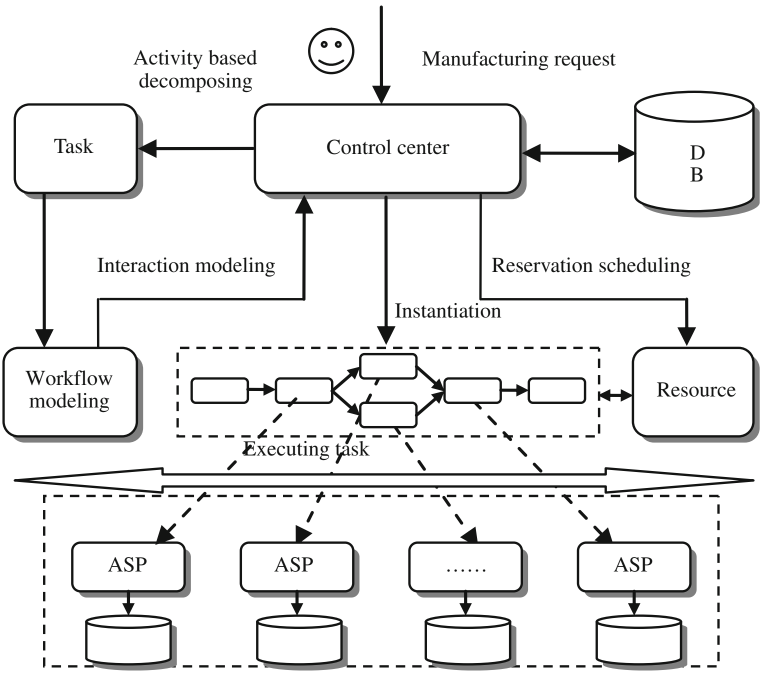

Fig. 15.1 Resource scheduling architecture of ASP platform

15.2.2 Business Process Model of ASP Platform

First of all, ASP providers register their manufacturing resource on the ASP platform according to manufacturing resource information stencil-plate which is provided by the platform system and publish some necessary information such as service time, service mode of resource. These ASPs and some other service resources constitute the service network. Then Clients can query the manufacturing resource according to their task to establish the service network of their tasks. The business process model is as shown in Fig. 15.2 which includes build stage and run stage.

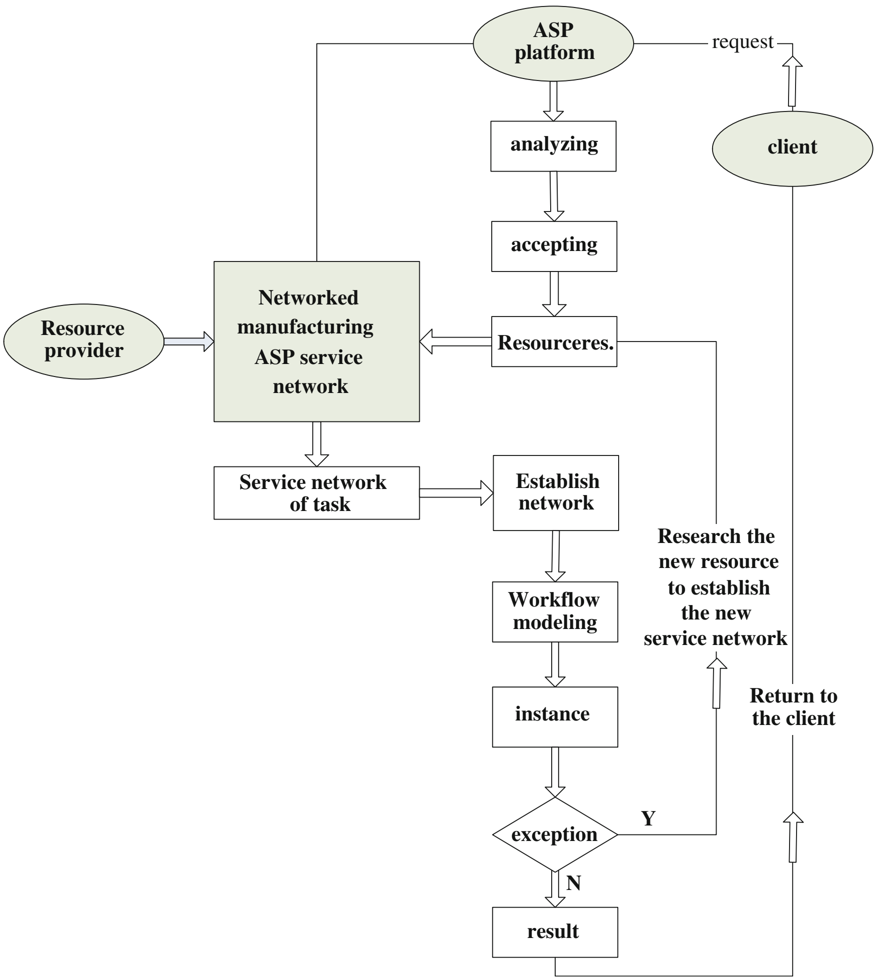

Fig. 15.2 Business process model of ASP based manufacturing resource scheduling

15.3 Resource Reservation Time Based Scheduling Model

15.3.1 The Concept of Resource Reservation Time

The manufacturing resource scheduling of distributed ASP platform is a representative resource sharing problem. There are two basal methods about scheduling of manufacturing system which include resource based scheduling and product based scheduling. Most researchers focus on product based scheduling, and they pay attention to the logic time sequences of production and Causal Relationships. However, networked manufacturing resources are complicated, heterogeneous, geographically distributed, and owned by different enterprises; furthermore, the manufacturing task is also uncertain. In the application, there are so many factors to influence the system such as location, using time of valuable machine, weather and important human resource. The resource provider is usually self-governed with client. So, we must firstly make sure the time slot of valuable machine to allocate among different projects. This constraint is called resource reservation time window. This kind of time here means absolute time.

The key of resource reservation model is to know its existence. Hence, a time-state table is maintained for each resource by ASP node. The reservation state of resource is shown in this table, so we can know available scheduling time of resource. For instance, the available scheduling time-state table of resource R is shown in Fig. 15.3. And we can see the distributing of executing task from t0 to t11. There are three kinds of resource state, the first is task executing state of resource; the second is reservation state of resource; the third is idle state of resource. For the executing state, we insure resource monopolistic until the task is finished; for the reservation state, we can negotiate about to execute the task with priority; for the idle state, we can allocate it to executing any task.

15.3.2 Basal Scheduling Object

There are distinct differences between scheduling of networked manufacturing ASP and scheduling of usual job shop, see as following:

1. Diversity of product, little batch and concurrent of more production;
2. Time uncertainties of production and urgency of due date;

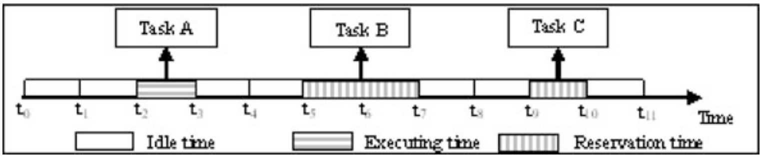

Fig. 15.3 The available scheduling time-state table of resource

3. Varieties and employability of machine;
4. Real control of scheduling to make use of manufacturing resource and response the dynamic characteristic of system.

After analyzing these differences, we consider the resource scheduling of networked manufacturing ASP from followed factors:

1. The objective associated with manufacturing requests of clients: due date, logistics time, waiting time, executing time and cost;
2. The objective associated with resource providers: resource utilization, profit margin and idle time;
3. The objective associated with ASP platform system: network load balance.

Due to distinct differences between scheduling time objective of networked manufacturing ASP and scheduling of usual job shop, scheduling time objective of job shop may be the more shorter the more better. However, scheduling time objective of networked manufacturing should be consistent with the plan of client. The shorter due date may add the capital investment and warehouse so as to influence the whole plan of client. For the resource provider, the resource utilization and profit margin should be ensured.

From above, the analyzing and combining of practical projects, we can conclude that the scheduling objective should be considered from the due date of client, profit margin of resource provider and network load balance of ASP platform system. We can depict this manufacturing task as a workflow based network graph $G = (V, E)$. In this equation, $V = \{0, 1, 2, \ldots, n+1\}$ denotes the set of manufacturing activities, and E denotes the set of connectors between manufacturing activities. In the resource scheduling of networked manufacturing, we consider not only the time sequence between activities but also the constraint of resource reservation time. The basal objective function and subject function is as following.

(1) The due date of client

$$\begin{cases} \text{minimize} & |T_{n+1} - T| \\ s.t. & T_0 \le T_1 \le T_i, \ldots, T_n \le T_{n+1} \\ & T_i - T_{i-1} \subseteq t_i^R \end{cases} \tag{15.1}$$

In this equation, T is the due date of task; T_0 and T_{n+1} are the begin time and end time of activity respectively, and they belong to dummy activity node; T_i is the real finished time; t_i^R is the reservation time of resource R for activity i. All the time are the absolute time except t_i^R.

(2) Profit margin of resource provider

$$\begin{cases} \text{maximize} & \sum_{k=1}^{n} C_k t_k^R, \quad k = 1, 2, \ldots, n \\ s.t. & t_k^R \subseteq |T_{n+1} - T_0|, \end{cases} \tag{15.2}$$

In this equation, C_k is the profit margin coefficient of resource R as executing activity k. The value of coefficient will change with different executing tasks. Furthermore, for the same task, the value may be different due to some factions as the length of executing time. And this value is decided by the client and provider of resource. t_i^R is the executing time of resource R for activity k. $|T_{n+1} - T_0|$ is the total available time of resource R for the activity k.

(3) Load balance of ASP platform system

$$\begin{cases} \text{minimize} & \left|G_i - G_j\right|, \\ s.t & i,j = 1, 2, \ldots, n \\ & i \neq j \end{cases} \tag{15.3}$$

In this equation, G_i is the total time including all the executing time of all the resource. This time belongs to the relative time conception.

The first two scheduling objectives are based on the request of client. And the third is for the system running, as well as improving the profit margin of all the resource providers. However, there is no uniform standard to measure the system' load. So, we introduce the total time of resource executing to measure it. This can solve the problem of network bandwidth bottleneck to balance the service time of each resource provider.

15.3.3 Heuristic Algorithm of Scheduling Model

This kind of networked manufacturing resource scheduling is very complicated. Plenty of researches indicate that these production scheduling problems belong to classical NP-complete problem. So there is no satisfying algorithm to draw an optimum result, and the usual solution is based on heuristic algorithm or some approximation algorithm. These solutions of mathematic models are very complicated processes. To reduce the operating complexity, the branch and bound algorithm is introduced. Firstly, the branch is executed according to each scheduling plan, and all of the plans form a scheduling search tree; and then, the bound is carried out according to the time sequence constraint and resource reservation constraint to get rid of the impossible plans; all the steps are repeated more times; Finally, an optimum scheduling plan is achieved.

15.4 Conclusions and Prospects

The problem of poor service ability and network bandwidth bottleneck currently can be solved by adopting the distributed ASP model. The resource reservation based scheduling is propitious to control the current state of manufacturing resource and to deal with the exceptions during the dynamic scheduling. So the available resource can be rapidly located to establish the new service network. And this is a great choice for the dynamic networked manufacturing as well as employment relation between clients and providers. However, the implement of distributed system is in leading strings, we have so much work to lucubrate such as the cooperation between more workflows, resource and more tasks, and so forth.

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Chapter 16
Design of NC Code Interpreter with C Language in Embedded NC System

Pu-bin Wang and Yu-xiu Shang

Abstract By analyzing the characteristics of NC codes, a method of interpreting NC part program for Embedded Control system is introduced in this paper. A NC code parsing program module written with C language has been designed. The main functions of the program are to check G code expressions and to extract the messages of all addresses and numbers included in NC blocks. With the features of direct frame, ordered statements, and high running efficiency, the program module can be referenced in developing embedded NC software.

Keywords C51 source code · C programming · Embedded control system · NC code interpreter

16.1 NC Part Program Format

Word address is the most common programming format used for NC programming systems (Krar and Gill 1999). In this format, NC part program is made up of distinct units of instruction called blocks, each block consists of several words, and a word is composed of an address and number. By convention, the words in a block are given in the following order (Groover and Zimmers 1984):

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N-words	this is used to identify the block.
G-words	this is used to prepare the controller for instructions that are to fellow.
X-, Y-, Z-words	these give the coordinate positions of the tool.
F-word	this specifies the feed in a machine operation.
S-word	this specifies the cutting speed of the process, the rate at which the spindle rotates.
T-word	this specifies which tools to be used in the operation.
M-word	this is used to specify certain miscellaneous or auxiliary functions which may be available on the machine tool.

16.2 Functions of NC Code Interpreter

NC code interpreter is a software module in CNC machine tool control kernel, which translates the part program consisting of G&M-code commands and related addresses such as S, T, and F into internal commands for moving tools and executing auxiliary actions. Following is the major functions of the interpreter (Suh et al. 2008a).

Word parsing: this module interprets the part program in CNC control unit memory block by block. For every block, the module reads the address character of a word and checks it valid or not. Then the module reads the number of the word and make sure it is within the range of CNC system. While both the address and number are valid, the module makes a meaningful word and calls the functions related with it to perform farther treatment.

Translating data format: while the interpreter has read a whole block, a data translating module should be called that translates all the numbers in the block to internal data and stores the execution result in the internal memory. In addition, this module generates the data required for executing the modal code such as G01, G02, etc. For example, float coordinate position should be converted to integer pulse number in an open loop CNC system.

Path generating: this module generates the position data based on the programmed coordinates. In this module, the computation for mapping from work piece coordinates to machine coordinates, tool compensation, and the axis limit is carried out.

Error handling: if there is an error in a part program, the error should be noticed and the user notified. This module is responsible for this.

16.3 Introduction of Embedded NC System

An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is specifically designed for a particular function. Industrial machines, automobiles, medical equipment, cameras, household appliances, airplanes, vending machines and toys are among the myriad possible hosts of an embedded system (Qian et al. 2009a). If an embedded system includes some NC functions such as a few of G&M functions, it may be described as an embedded NC system.

Figure 16.1 shows an embedded NC system hardware platform (Liu 2010). The C8051F040 microcontroller which is used as CPU executes the control program saved in system ROM area. The actions of MCX314 chip are receiving commands come from C8051F040 and driving three step motors to run.

The close relation between embedded software and the underlying customized hardware platform demands special procedures when developing embedded software. By its nature, embedded software design has to deal with hardware specific tools, such as processor specific instructions and simulators, hardware simulators and emulators (Gajski et al. 2009). For example, if the C8051F040 chip to be selected in embedded applications, we can use Keil C51 development tools and the C8051F040DK development kit by the Silicon Laboratories (Qian et al. 2009b).

In the CNC system, various tasks from the control kernel, man machine interface (MMI), and PLC units are executed simultaneously and each task requires real time operation. Therefore, it is essential to use a real time operating system in order to operate various real time tasks in a multiprocessing environment (Suh et al. 2008b). Some real time operating systems such as WinCE, μC/OS-II are used in embedded NC systems (Xu et al. 2007; Gan et al. 2009). But for simple applications, the interrupt priority frame is used as well, in which there are one main program and several interrupt routines (Zurell 2000).

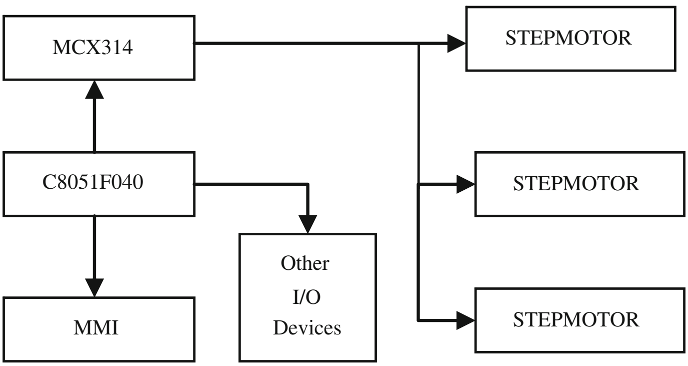

Fig. 16.1 Hardware platform in an embedded NC system

16.4 Program Design with C Language

The interpreter of the NC system is the software module of the numerical control kernel. Depending on the requirements of users, it may be complicated or simple. Furthermore, it can be designed in real time operating system or in interrupt priority frame (Zhang and Yao 2010). As mentioned in the previous section, 8051 series microcontrollers can be developed with Keil C51 development tools, so we use those tools to design a part of NC interpreter program as an illustration. Figure 16.2 shows the flowchart of the parsing function we have been developed in an embedded NC system, which has the functions of searching address, examining numbers, and saving data to memory.

First, an address set for NC code has been defined by the keyword of 'enum' in C language. We also define a const string consist of all address characters for searching the index of each address in the set. Then we should define all numbers in a block as a structure variable type named 'block'. The member of Lenth_number in the block structure is used to save the numbers of Address X to R. The member of FSTDHN_number is used to save the numbers of Address F to N. G & M codes are grouped into different categories of related functions, as listed in Table 16.1 (Mattson 2004). They can be found in the 'switch' statements codes in the C51 program source code followed also. The member of M_number can

Fig. 16.2 Flowchart of the parsing function

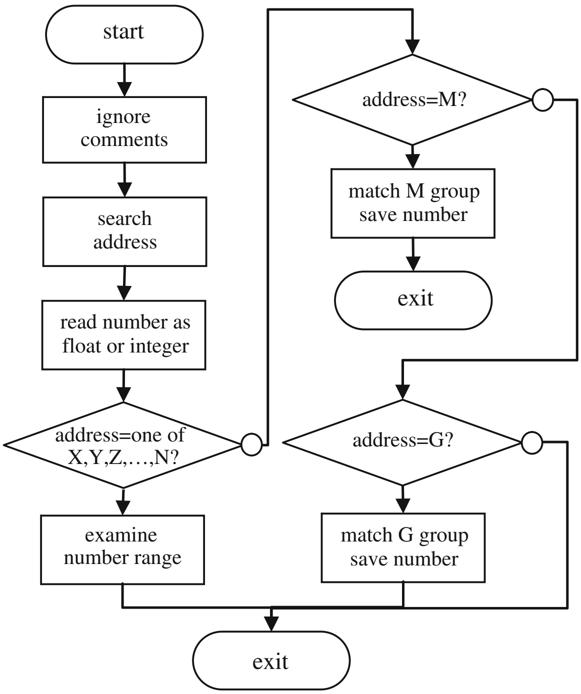

Table 16.1 G & M code functional groups

Addresses	Codes
G	G00, G01, G02, G03
	G90, G91
	G17, G18, G19
	G40, G41, G42
	G43, G44, G49
	G54, G55, G56
	G80, G81, G82
	G04, G92
M	M01, M02, M06, M30
	M03, M04, M05
	M07, M08, M09

save three numbers of M codes, and the member of G_number can save eight numbers of G codes in an NC block.

The parsing function we designed performs several basic works for NC code interpreting from a given NC block messages tailed with ‘\0’ orderly. In the first place, it searches the NC code comments which are started at ‘(’ and ended at ‘)’, and replaces them with spaces which will be ignored later. So the block messages are made up of addresses and numbers only. Then the function searches an address character in the block messages by the strpbrk() function in C51 library and gets its index in the NC address list that we preset by the strppos() function in C51 library. If the address is valid, a number will be read from the input messages. Else, the function returns an error number. According to the address has been read, the number may be translated as a float by atof() function or an integer value by atoi() function (Lan 2008).

In the end stage, base on the address index, the number has been read must be saved to a variable belong to the block structure. It is important to fix on which address or code group to match the index. The ‘switch’ statement in C language is used in order to make the program frame clearly and easy to read (Pardue 2005). We can see the C51 program source code list below for details.

```
/*   NC block parsing program source code    */
#include <stdlib.h>
#include <string.h>
#include <ctype.h>
#define BLOCK_CHK_DONE                    0
#define BAD_COMMENTS                            1
#define UNKNOWN_ADDRESS                   2
#define UNKNOWN_MCODE                     3
#define UNKNOWN_GCODE                     4
#define UNKNOWN_NCCODE                    5
#define LENGTH_OUT_OF_RANGE          6
#define FS_OUT_OF_RANGE                   7
#define TDHN_OUT_OF_RANGE            8
#define LENGTH_SCALE                 1000
//define enumerated types
enum Address {X,Y,Z,I,J,K,R,F,S,T,D,H,N,M,G};
code const char ADDRESS_TAB[]="XYZIJKRFSTDHNMG";
//declare the template of block structure
struct block
{
        long Lenth_number[R+1];
```

```
        int FSTDHN_number[6];
        char M_number[3];
        char G_number[8];
};
//define number limits
code const float MAX_Lenth_number[R+1]=
{10000,8000,2000,1000,1000,1000,1000};
code const float MIN_Lenth_number[R+1]=
{-10000,-8000,-2000,-1000,-1000,-1000,-1000};
code const int MAX_FSTDHN_number[6]=
{10000,8000,3299,3299,3299,30000};
/*          parsing function                    */
char parsing(char *cmdptr,struct block *blkptr)
{
        char index,*p,*p1;
        int i;
        float f;
        /*      replace Comments with spaces  */
        for(p=cmdptr;*p!='\0';p++)
        {
                p1=strchr(p,'(');
                if(p1==NULL)break;
                p=strchr(p1,')');
                if(p==NULL)return(BAD_COMMENTS);
                while(p1<=p)*p1++=' ';
```

```
}
/*parsing block word by word*/
for(p=cmdptr;;)
{
//ignore spaces
        while(isspace(*p))p++;
//point to the address of the current word
        p1=strpbrk(p, ADDRESS_TAB);
//if    no address found,return
if(p1==NULL)return(BLOCK_CHK_DONE);
//get address index
        index = strpos(ADDRESS_TAB,*p1);
//no valid address was found,return error code
        if(index==-1)return(UNKNOWN_ADDRESS);
/*ignore spaces then p point to the number
of current word*/
        for(p=p1,p++;isspace(*p);p++);
//convert the ascii number to float or integer
        if(index<T)f=atof(p);
        else i=atoi(p);
        switch(index){
                case X:case Y:case Z:
    case I:case J:case K:case R:
                        //range
        if(f > MAX_Lenth_number[index]||
        f < MIN_Lenth_number[index])
```

```
return(LENGTH_OUT_OF_RANGE);
//save address index
            blkptr>Lenth_number[index]=
(f*LENGTH_SCALE);                       break;
      case F:case S:
            //range
            if((int)f > MAX_FSTDHN_number
[index-F]||(int)f < 0)
            return(FS_OUT_OF_RANGE);
            blkptr->FSTDHN_number
[index-F]=(int)f;
            break;
      case T: case D:case H:case N:
            if(i > MAX_FSTDHN_number
[index-F]||i < 0)
            return(TDHN_OUT_OF_RANGE);
            blkptr->FSTDHN_number[index-F]=i;
            break;
      case M:
            switch(i){
                  case 0:case 1:case 2:case 6:case 30:
                        blkptr->M_number[0] = i;break;
                  case 3:case 4:case 5:
                        blkptr->M_number[1] = i;break;
                  case 7:case 8:case 9:
```

```
                        blkptr->M_number[2] = i;break;
                    default:
        return(UNKNOWN_MCODE);
                }
                break;
            case G:
                switch(i){
                    case 0:case 1:case 2:case 3:
                        blkptr->G_number[0] = i;break;
                    case 90:case 91:
                        blkptr->G_number[1] = i;break;
                    case 17:case 18:case 19:
                        blkptr->G_number[2] = i;break;
                    case 54:case 55:case 56:
                        blkptr->G_number[3] = i;break;
                    case 40:case 41:case 42:
                        blkptr->G_number[4] = i;break;
                    case 43:case 44:case 49:
                        blkptr->G_number[5] = i;break;
                    case 80:case 81:case 82:
                        blkptr->G_number[6] = i;break;
                    case 4:case 92:
                        blkptr->G_number[7] = i;break;
                    default:
          return(UNKNOWN_GCODE);
```

```
                        }
                        break;
                    default:return(UNKNOWN_NCCODE);
                }//end of switch(index)
        }//end of for
        return(BLOCK_CHK_DONE);
}
/*      Memory Model:Large    */
struct block blk1;
char test_block[]=
"N120 G01(Line interpolation) X10.005 Y-6 F80(End)";
void main( )
{
        int n;
        while(1)
        n = parsing(test_block,&blk1);
}
```

16.5 Discussion

There are a number of embedded NC systems have been developed yet. Though some of them are complicated, but they should not be equal to CNC system. Embedded systems with complicated hardware and/or software would increase developing difficulties and reduce its superiority. In general, with fewer functions then that of CNC systems, embedded NC systems are more suitable for some special applications in numerical control field (Li et al. 2012). So its software should be simple then that in CNC systems.

On the other hand, NC part programs can now be prepared with the use of inexpensive computers, using graphical interface. Cost is no longer an issue, even small machine shops can afford a programming system in house. It seems that the manual programming is on the decline. In terms of actual use, this is probably true. The manual programming may be use somewhat less frequently today and eventually will be used even less (Smid 2003). As programming with CAD/CAM software, errors in NC part programs will be reduced persistently. This will decrease the complexity of NC interpreter obviously. The program source code designed in this paper can offer a direct, ordered, and effective C language module to develop embedded NC interpreters.

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Chapter 17
Empirical Researches (Based on SEM) on the Factors that Affect Manufacturing Performance

Chang-yi Liu

Abstract The existing researches used to explore the factors that may affect manufacturing performance assume the uncertainty of manufacturing environment as an exogenous variable so as to neglect the indirect influence of some factors, such as manufacturing flexibility, product diversity. And besides, the researches focus more on financial performance. The thesis will develop the manufacturing performance into three dimensions—the time performance, quality performance and efficiency performance, to research the relation among manufacturing environment, product diversity and manufacturing performance, considering the uncertainty in the manufacturing environment, constituting theoretical analysis model of manufacturing performance treating the uncertainty as intervening variable, regarding a semiconductor manufacturing company as specimen, and analyzing the theoretical model depended on the method of structural equation model. Eventually, it will propose recommendations for the manufacturer on the promotion of manufacturing performance.

Keywords Efficiency performance · Internal uncertainty · Quality performance · Structural equation model · Time performance

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17.1 Introduction

The uncertainty of modern manufacturing environment is increasing because of the factors, including the product diversity, the time-based competition and the condensing life span of the product. However, the manufacturing flexibility regarded as the functional mechanism response to uncertainty and contributing to the attainment of competitive dominance in the changeable environment, come to the pursuit of manufacturing enterprises (Leachman et al. 2005). The important tasks in the face of many a company are how to manage product diversity and confirm the fitter flexibility standard. While top priority of the task is to sort through the relations among the product diversity, manufacturing flexibility and every manufacturing performance indicators. Although there are plenty of literatures about the influences of product diversity and manufacturing flexibility have on manufacturing performance, large majorities of them concentrate on the connections among sale revenue, the corporate profits and other financial performances (Matsubayashi et al. 2009). Nevertheless, the researches about how diversity and flexibility affect quality, time, facility efficiency and other non-financial performances are rare. In addition, all the researches existing regard the uncertainty of manufacturing environment as an exogenous variable thus resulting on the neglect of the indirect impacts the diversity have on manufacturing performance via uncertainty and the shortage of effective measure towards the essence that it is through uncertainty that manufacturing flexibility has an influence on manufacturing performances.

17.2 Theoretical Analysis and Research Framework

Routing flexibility and machine flexibility are classified as manufacturing capacity of internal flexibility in manufacturing system, both of which contribute to the expansion of the production workshop and the increase of combination flexibility. Yang et al. (2007) found that production cycle is strictly decreasing function to routing flexibility when defining routing flexibility with individual production batch number of alternative work station and evaluating its effects on production cycle. In addition to production cycle, the existing literature also pointed out that the routing flexibility is conducive to the improvement of product quality. For example, Wahab et al. (2008) when adopting the field data of a beverage company and analyzing the influences the frequency of production changes have on acceptance rate, it can unveil that the reduction of frequency of production changes is conducive and beneficial to acceptance rate, which means the reduction of products with flaw. Because of the permissibility of machine flexibility to lower yield, which makes it convenient to balance the workload of each work station, machine flexibility help to promote the efficiency of utilization of machine. Under the circumstance of flexibility manufacturing system, it can be discovered that machine flexibility has a positive impacts on the productivity and the rate of capacity utilization though the simulative analysis assuming that machine flexibility is measured by the number of product family which machines are capable of handling while testing the influences machine flexibility have on productivity of manufacturing system and the rate of capacity utilization (Sheikhzadeh et al. 1998). Hence, according to the influences of flexibility on manufacturing performance, the research brings forward a hypothesis as follows:

H1: The manufacturing performances will be directly proportional to the increase of the internal flexibility.

In addition to the theoretical research, a number of literatures demonstrate the relations between product diversity and the manufacturing cost, most of which are in favor of the positive relations between them (Hatzikonstantinou et al. 2012). Meanwhile, some literatures index that the advance of product diversity can causes the decrease of manufacturing performance not inclusive of the cost. For example, Benjaafar et al. (2004) shows that product diversity and the production cycle are positively related and displayed that the product diversity is directly proportional to the scheduled time of machines as well. McDuffie et al. (1996) demonstrates, based on the practical examples of assembly industry of automobile, that the complexity of part assembly will rise as the increase of product diversity, which means the decline of productivity of workers. Swaminathan and Nitsch (2007) points out that the increase of product diversity will bring about the rise of complexity of batch production, the shortage of crude materials and the probability of line stop, thus inciting the higher frequency of reject and refashion. Based on the backdrop of the industry of textile, Anderson (2001) displays that the climb of product diversity will lead to the fall of quality performances. Accordingly, we can anticipate that the product diversity has negative impact on time performance, quality performance and productivity performance. The hypothesis 2 can be brought forward as follows forasmuch the former researches.

H2: The manufacturing performance will decrease as the increasing product diversity.

Uncertainty of manufacturing environment mainly reflects in the variation of processing time, arrival time and demand of products, these mutations will not only affect the flow of raw materials in the manufacturing system and utilization of equipment capacity, meanwhile it will also result in reduction of time and cost performance, Specifically, the input rate should be equal to the output rate in a stable production system, but when variation emerges in the system, such stable situation can no longer be maintained. Due to the fact that it is difficult to predict when the production volume can reach the workstation, the complexity of production planning will increase. The average waiting time for the production volume is thereby prolonged, and each workstation will have more in-process inventory, resulting in a worse situation in terms of the performance of production time, delivery date, etc. Tang (1990) adopts a mathematical method to prove that the uncertainty of the manufacturing environment will cause the decline in output and elevation in the level of Safety stock. Therefore, we can anticipate the relationship between uncertainty and manufacturing performance.

H3: Manufacturing performance decreases with the increase of the internal uncertainty.

Concerning how machine flexibility and routing flexibility affect environmental uncertainty, it can be illustrated by two viewpoints. The first is that some studies, based on the mathematical model and simulation analysis, show that internal uncertainties such as stop of machines, urgent order insertion and reproduction originating in the process of manufacturing will be reflected in arrival time variation and process time variation, thus exerting a negative impact on the production cycle, while machine flexibility and routing flexibility can reducing the impact of environmental uncertainty on manufacturing performance, by changing the relationship between the environmental variation and manufacturing performance, manufacturing flexibility can take in the environmental uncertainty, and then it can achieve the improvement of manufacturing performance (Gerwin 1993). Another research puts forward a kind of theoretical framework for the manufacture flexibility, demonstrating that manufacturers can reduce the impact of environmental uncertainty on output variation by upgrading manufacturing flexibility and then achieving the improvement of manufacturing performance (Merschmann and Thonemann 2011). All in all, no matter which point you may agree to, but it is universally acknowledged that the benefits of manufacturing flexibility results from the reduction of impact of environmental uncertainty on manufacturing performance. Therefore, we bring forward the Hypothesis 4 (as below):

H4: As manufacturing flexibility raises, internal uncertainty will reduce.

In general, most of external uncertainties are exogenous, uncontrollable factors, while internal uncertainties, in addition to some unexpected changes taking place in the course of manufacturing, will also be driven by external uncertainty, for instance, when there is a high variability in time and the quality of raw materials delivered by suppliers, it will be more likely to lead to a great uncertainty of shortage of raw materials in process of manufacturing, making production planning more complex. Any increase in product diversity and the alteration of customers' demands for product quality or delivery date will result in conflict between the utilization of production resources and production scheduling, thus increasing the internal uncertainty, in other words, internal uncertainties are driven by external uncertainties and among these external factors (Zhang and Tseng 2007). Product diversity is the main contributor to the increase of external uncertainty, Shamsuzzoha and Helo (2009) points out that when product diversity increases, it will lead to a decreased demand for some products and a much higher volatility, that is to say, it can cause an increase in product demand variability. On the other hand, the frequency set for the machine will also increase with product diversity increasing. However, the frequency itself is a function of environmental variability. Therefore, we can come to a conclusion that there is a positive correlation between the diversity and internal uncertainty, so the Hypotheses 5 (H5 as follows) is put forward:

H5: Internal uncertainty will increase with product diversity increasing.

Based on the abovementioned analysis, the research framework of this text is shown in Fig. 17.1:

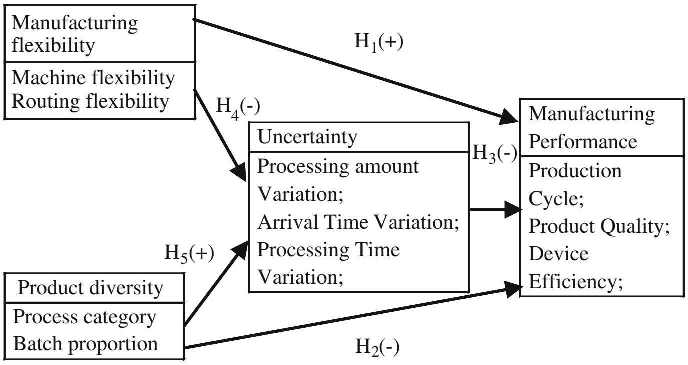

Fig. 17.1 The research framework related to the impact of manufacturing flexibility and product diversity, and uncertainties on manufacturing performance

17.3 Empirical Researches

17.3.1 A Sample and Data Collection

This research adopts an empirical approach, using data from one semiconductor manufacturing enterprise in Shanghai, by means of field interviews, observation and reading relevant written information, the author can understand the production process, process performance. Besides, the author has also collected lots of data associated with machine performance for 6 months, the data includes those samples produced in a span from March 2010 to August 2010, and some samples unfinished during the required time are deleted, and a total of 1513 batches of production lot-sizing have been included in the research sample finally.

17.3.2 Research Method Design

Based on the SEM, this research is used to make a routing analysis with a view to completing the validation of the theoretical analysis framework, that is to examine direction of the effect and its effect between variables presented in the research framework. The maximum likelihood estimation method is adopted in the aspect of the estimation of parameters; meanwhile, we use the standardized t to test the significance of path coefficient. The research data is entered in the software Excel 2000, the software SPSS Ver.11.5 is used for statistical analysis and software Lisrel Ver.8.54 for SEM.

Table 17.1 Descriptive statistics

Variables	Specimen number	Minimum	Maximum	Average	Standard error
Production cycle (min)	3156	1.430	4070.550	153.470	231.669
Product quality	3033	0.8600	0.1000	0.9935	0.0070
Equipment efficiency (%)	3156	0.200	100.000	53.320	23.700
Machine flexibility	3156	1.000	26.000	4.000	3.742
Path flexibility	3156	1.000	33.000	9.000	8.613
Process category	3156	1.000	15.000	6.580	3.520
Dispatch proportion	2989	0.000	1.000	0.1600	0.2200
Processing number variability	4537	0.000	23.000	0.650	0.567
Arrival time variability	3995	0.020	6.132	0.596	0.664
Processing time variability	3641	0.030	65.772	3.790	3.288
Total production number	3156	29.000	237835.000	23534.340	32195.590
Capacity utilization ratio (%)	3106	0.000	100.000	77.450	24.695

17.3.3 Analysis of Empirical Results

17.3.3.1 Descriptive Statistics and Correlative Analysis

Descriptive statistics are listed in Table 17.1. The absolute values of the correlative coefficient between the variables are less than 0.6, indicating that there are no co-linearity problems among variables.

17.3.3.2 Path Analysis Based on the Relationships Between SEM Variables

The research serves to using SEM methods to verify the path model which shows the relationships of manufacturing flexibility and product diversity, uncertainty and manufacturing performance. The structural diagrams are as follow, namely, Figs. 17.2, 17.3 and 17.4.

We can see from the above three diagrams that:

Among the products handled in a given period, the much more higher proportion of the dispatch is, the more it will lead to the extension of the production cycle ($r = 0.335$), the decrease of product quality and equipment efficiency ($\gamma = -0.283$; of $\gamma = -0.156$), and it will also increase uncertainty in the manufacturing environment. Specifically speaking, it will lead to the increased variability of the arrival time ($r = 0.297$), the increase of variability in processing time and processing quantity($r = 0.302$; $r = 0.331$). However, uncertainty will have a negative impact on manufacturing performance. What's more, arrival time variability and processing time variability will also lead to the extension of the

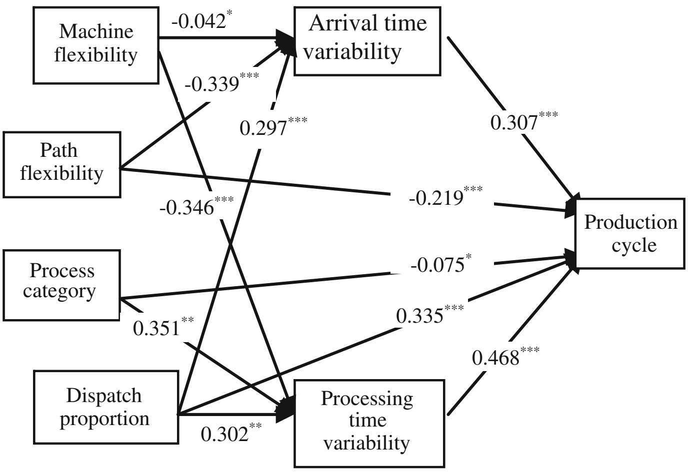

Fig. 17.2 Structural diagram of manufacturing flexibility and product diversity, uncertainty and production cycle. *Note* Data for the standardized path coefficient γ. ***Indicates significance level <0.001, **indicates significant level <0.01, *indicates significance level <0.05

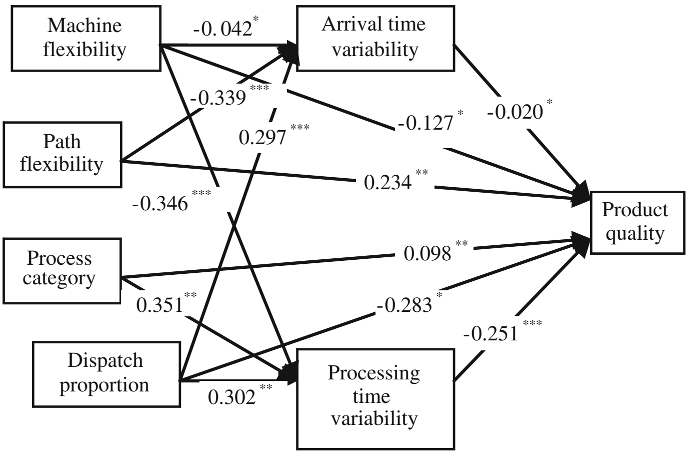

Fig. 17.3 Structural diagram of manufacturing flexibility and product diversity, uncertainty and product quality. *Note* Data for the standardized path coefficient γ. ***Indicates significance level <0.001, **indicates significant level <0.01, *indicates significance level <0.05

production cycle ($\gamma = 0.307$; of $\gamma = 0.468$), and at the same time will lead to a decline in the level of product quality ($\gamma = -0.020$; of $\gamma = -0.251$). While the processing quantity variability and arrival time variability can also reduce the overall efficiency of the equipment ($\gamma = -0.292$; of $\gamma = -0.282$). In another words, the urgent proportion not only results in a direct result of lower manufacturing performance, but also causes a deterioration of the manufacturing performance indirectly through the uncertainty of the manufacturing environment.

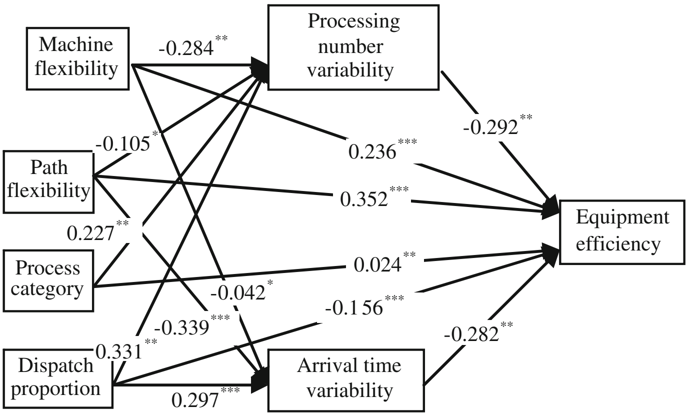

Fig. 17.4 Structural diagram of manufacturing flexibility and product diversity, uncertainty and device efficiency. *Note* Data for the standardized path coefficient γ. ***indicates significance level <0.001, **indicates significant level <0.01, *indicates significance level <0.05

When there are more varieties of industrial arts, it will shorten the production cycle (r = −0.075), improve product quality (r = 0.098), increase equipment efficiency (r = 0.024). That is to say, the increasing number in the varieties of industrial arts will help to enhance manufacturing performance. The results are actually consistent with the previous regression analysis. In the meanwhile, varieties of industrial arts also has a positive impact on the processing time variability and processing quantity variability ($\gamma = 0.351$; of $\gamma = 0.227$), and then through the uncertainty of the environment it will cause the extension of the production cycle and the decline in quality and equipment efficiency. Therefore, the impact of industrial arts varieties on the manufacturing performance depends on the direct impact and relatively big or small indirect impact caused by uncertainty.

The increase of machine flexibility can improve equipment efficiency (r = 0.236), and also at the same time by reducing processing quantity (r = −0.284) and arrival time variability (r = −0.042), it makes the device efficiency to further enhance indirectly. Maybe due to the increase of machine flexibility, it leads to production change increase in number, thus causing a negative impact on the product quality (r = −0.127). However, by reducing arrival time variability (r = −0.042) and processing time variability (r = −0.346), we can enhance quality performance and time performance indirectly.

Increasing routing flexibility can shorten the production cycle (r = −0.219), improve the product quality (r = 0.234) and device efficiency (r = 0.352), which has a positive impact on manufacturing performance. But at the same time, routing flexibility also has a negative impact on processing quantity variability and arrival time variability ($\gamma = -0.105$; $\gamma = -0.339$), that means a increase in routing flexibility can reduce the uncertainty of the manufacturing environment, thus we can improve manufacturing performance through uncertainty indirectly. Impacts of each variable on manufacturing performance are shown in Table 17.2.

Table 17.2 Analysis of influential effects of each exogenous variables on the manufacturing performance ($N = 2894$)

		Machine flexibility	Path flexibility	Process category	Dispatch proportion	Processing number variability	Arrival time variability	Processing time variability
Production cycle	Direct effect	–	−0.219***	−0.075*	0.335***	–	0.307***	0.468***
	Indirect effect	−0.175**	−0.104***	0.164**	0.232**	–	–	–
	Whole effect	−0.175**	−0.323***	0.089*	0.567**	–	0.307***	0.468***
Product quality	Direct effect	−0.127*	0.234**	0.098**	−0.283*	–	−0.020*	−0.251***
	Indirect effect	0.088*	0.007**	−0.158**	−0.142**	–	–	–
	Whole effect	−0.039*	0.241**	−0.060**	−0.425*	–	−0.020*	−0.251***
Equipment efficiency	Direct effect	0.236***	0.352***	0.024**	−0.156***	−0.292**	−0.282**	–
	Indirect effect	0.095**	0.126*	−0.066**	−0.180**	–	–	–
	Whole effect	0.331**	0.478*	−0.042**	−0.336**	−0.292**	−0.282**	–
χ^2/df = 1.537, CFI = 0.913, NNFI = 0.925								

Data for the standardized path coefficient γ
$*p < 0.05$; $**p < 0.01$; $***p < 0.001$

17.4 Research Conclusions and Policy Recommendations

Firstly, manufacturing flexibility can improve manufacturing performance by reducing the negative impacts of environmental uncertainty. But different flexible form can respond to different environmental uncertainties and the impact on manufacturing performance is also different. Therefore, we recommend that companies should do in accordance with the characteristics of the various production plants as well as the performance indicators which are emphasized, and then adjust the flexible shape and flexible level as requested; though manufacturing flexibility may help to improve time and efficiency performance, but there are trade-offs in terms of quality performance, thus we suggest that enterprises should adopt multi-dimensional performance indicators to analyze manufacturing flexible in order to avoid making wrong assessments of the value of manufacturing flexible caused by specific performance indicators.

Secondly, the improvement of product diversity will lead to a lower manufacturing performance. But the same product diversity has a various magnitude of influence on performance indicators such as quality, time, and the impact of different products diversity on the same manufacturing performance is also different, indicating that enterprise should effectively manage products diversity to enhance manufacturing performance, and choose different management strategy according to the characteristics of different product mix; a increase in products diversity will lead to the improvement of the uncertainty in manufacturing environment while uncertainty has a significant impact on manufacturing performance, this fact suggests that uncertainty, existing in the manufacturing environment, is also an important factor in reducing performance. Therefore, enterprises who want to improve manufacturing performance should devote to reducing the level of uncertainty, or adopt management strategies to reduce the impact of uncertainty. While ignoring the impacts of uncertainties could lead to the underestimation in the cost of product diversity, what's more, to the sub-optimal management decisions of products diversity.

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Chapter 18
Extraction of Energy Unit for Electromechanical Products Based on Extension Theory

Run-liang Dou and Hui Zheng

Abstract Energy-saving design is an important part of green design. Effective control of energy consumption during the whole life cycle is the crue to realize energy-saving design. There are many factors to affect the energy consumption. The definition of energy unit is put forward on the base of extension theory. Matter-element character of a product is classified into two kinds, namely, functional character-unit and capable character-unit. Matter-element models of each phase in the whole life cycle are formalized respectively. And matter-element model of a product is built up based on energy unit. A three-dimensional model is advanced on the base of conjugated view, in the hope of getting instructions for the extraction of energy unit in the field of energy-saving design.

Keywords Energy unit · Extension · Energy-saving design

18.1 Introduction

So far, much research of product design has laid their attention on its function. Only when a product satisfies the functional demand, can it enter the market. In the face of the trend of increasingly decrease of global energy, energy crisis has triggered

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the extension of the product design from functional design to energy-saving design. For products with similar functions, implementing energy-saving demand is not only a new start of modern product design, but also a symbol of fulfilling energy-saving design. A product with optimal energy-saving capability has just indeed competence.

The character of energy saving is embodied at each phase of the whole life cycle. The performance of energy saving is largely determined by design stage. Product design is the core of manufacture in modern design theory. At each phase of the whole life cycle, the factors which influence energy consumption are different and their mechanism of action varies. And some factors are acquired concretely, others are impossible.

Although many scholars have brought forward some valuably new ideas and methods in the field of saving energy, but most of them was the analysis of the energy consumption, supply and demand from the government view (Qu 1992; Chu 2000; Feng and Wang 2004). Only a minority has worked over the microcosmic model of energy consumption for discrete manufacture (Jie et al. 1998; Li et al. 2005; Liu and Xu 1995). This paper puts forward the concept of extended energy unit on the foundation of extension theory. A new idea which uses extended energy unit to motivate energy-saving design is advanced systematically. And extended energy unit is proved to be an effective tool to drive energy-saving design.

18.2 Basic Cell-Matter Element of Energy-Saving Design

18.2.1 Break Down of Users' Demands

A product's quality is determined by both its function and capability (Xing 2010). Among products with the same or similar function, users would like to choose one with better performance to deliver service. The main activity of energy-saving design is deployed to improve its energy-saving nature on condition that its function is ensured. When a deviser plans an energy-saving product, he must make clear both users' functional and performance demands. Therefore, expression of function and relation between performances become the chief problem for energy-saving design.

Thus, a designer has to face two sides of users' demand at the same time: a product's function (F) and its energy-saving trait, which establish "F-ES" system together to support and determine energy-saving design. According to the composed principle of extension theory, "F-ES" system can be formalized as: $S = F \oplus ES$.

The division of users' demand is beneficial to energy-saving design. On the premise of basic function guarantee for most product planning, if some parts are simply modified or improved, the product performance and consumer satisfaction can be upgraded greatly.

18.2.2 The Character of Energy-Saving Product and Its Denotation

The sequential triple $R = (N, c, v)$ of extension theory is utilized as the elementarily logical unit to describe the energy consumption model for mechanical products of the whole life cycle, which is called matter element of energy-saving design. N represents the product, and it may stand for products at different level for matter element at different level, which can be variant phase of the whole life cycle or a concrete production process. C is on behalf of product trait. V represents the quantity value of product trait. (c,v) is named as characteristic element, and is denoted by M = (c,v). If c is functional character, M acts as functional characteristic element, and is denoted by Mf. at the same time, if c is performance character, M is called as performance characteristic element, and is denoted by Mq. A product's characteristic element is composed of functional characteristic element and performance one together, namely, M = Mf $\oplus$ Mq. Mf and Mq can also not only appear as the form of child matter element, but also delegate affair matter element and relation matter element.

The matter element of energy-saving design mentioned above can better embody the thought of "F-ES" system. R corresponds with S. Mf agrees with F, and Mq matches with ES. Consumers' demands include both functional and capable requirements. By matter-element model, these demands can be formalized uniformly as matter element or child one. Each layer is the child matter element model of its upper layer, illustrated as Fig. 18.1.

18.3 Three-Dimensional Identified Model of Energy Unit Based on Conjugated View

During the process of energy-saving design, the key factors which influence the energy-saving performance must be found out in order to shorten the design cycle and enhance the energy-saving performance (Fig. 18.2).

Energy unit is a kind of performance characteristic element which plays an important role in the direct or indirect energy consumption at each phase of the whole life cycle. Whether or not a product has excellent energy-saving performance depends on energy unit.

The definition of energy unit has a broad meaning, which can be a performance characteristic element with only one characteristic element, and can also be a complex one with a few characteristic elements.

The effective extraction of energy unit can not only better deliver the design intent and idea, obtain the purpose of standardization, but also provide preferable support under parallel design environment. That is to say, the achievement of energy unit is the chief problem to settle.

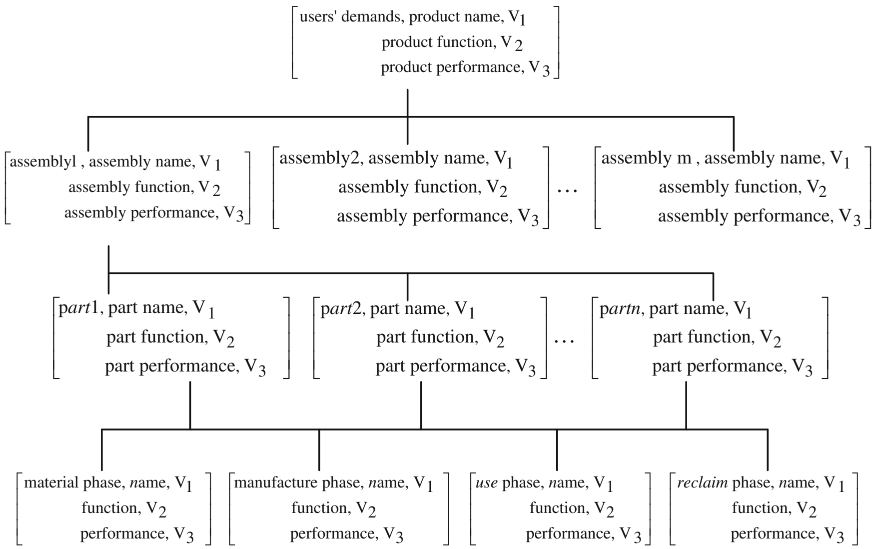

Fig. 18.1 Product matter-element model based on “F-ES” system

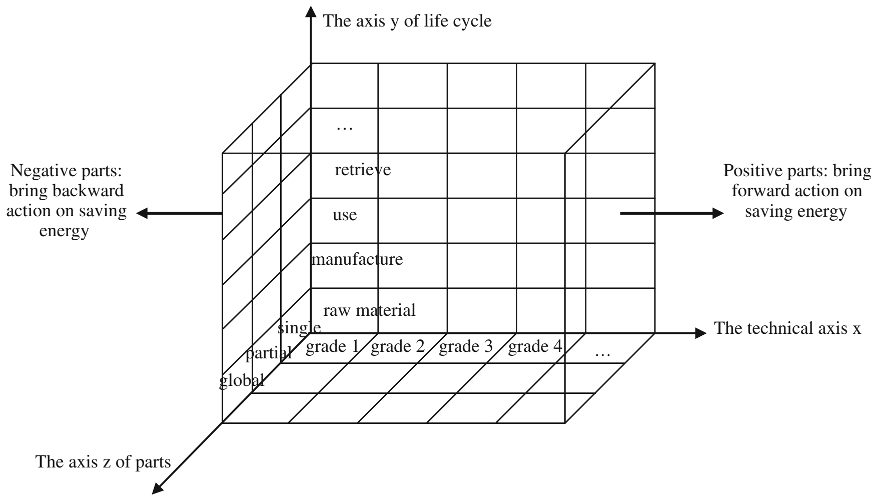

Fig. 18.2 The three-dimensional identified model of energy character based on conjugated view

The extension theory deems that anything has two opposite sides. The contrariety exists at a certain character. The quantity value of a thing about a certain character is the integrated result of both positive and negative value. The positive (negative) value is called positive (negative) part. The change of quantity value will lead to the corresponding change of things, while the change of conjugated part will arouse the change of function.

For a given product N, its character is c, and its energy consumption value is v. if v(c) $\geq$ 0, c is called the positive part on energy-saving character of N, shortened as c^+; if v(c) $\leq$ 0, c is called the negative part of N, and shortened as c^-. The entirety of positive parts is names as orthomere, marked as $ps(v)N = \sum c^+$; The entirety of negative parts is named as paramere, marked as $ng(v)N = \sum c^-$. Faced with the technical axis, the model for identification of energy trait could be recorded as $N = ps(v) \times ng(v)N$. The technical axis of energy trait identified model mainly is used to describe the effect for grade of energy-saving trait.

18.4 Conclusion

Energy-saving design is the top priority of green design and manufacture up to date. Energy unit is proposed to motivate a product design in this paper. Functional and capable demands for mechanical products are formulized by extension theory. And a three-dimensional model for the extraction of energy unit is put forward.

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Chapter 19
Fuzzy Appraisal on Implementation Effect of MES Based on New Membership Degree Conversion Algorithm

Hong-liang Zhang, Zhan-wen Niu and Li-Jian Cheng

Abstract With development of economic globalization, the competition environment of enterprises in China is becoming more and more severe. This background demands enterprises to introduce new management concept and advanced management tool. In order to keep leader position in automotive industry in China and actively take participate in international competition, FAW Jie Fang Automotive Company turns to MES. This paper summaries related research about MES, and introduces the implementation situation of MES in Jie Fang Company. In order to appraise the implementation effect, the new membership degree conversion algorithm of fuzzy evaluation model is introduced. In appraisal process, the membership degree vector is realized by comprehensively considering classification weights and importance weights of the indexes. The evaluation result under new algorithm is much more scientific, and the result not only shows what level the MES of Jie Fang has reached, but also gives out the weak link, which needs to improve in future.

Keywords Fuzzy evaluation · Implementation effect · MES · New algorithm of membership degree conversion

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19.1 Introduction of MES

Manufacturing execution system (short of MES) firstly appeared in late of 1970s, which can only solve specific problems, such as equipment monitoring, quality management, and production schedule tracking at that time. For example, the specific MES for manufacturing stamping die (Choi et al. 1995). So in initial stage, although MES was a promotion to production management, it caused two problems, the information island between horizontal system and the missing ring of schedule (such MRP, MRPII) as well as distributed control system to MES.

In order to solve these problems, the integration of production schedule tracking, quality information system, equipment management system reached agreement in the late 1980s. Under such background traditional MES (short of T-MES) appeared. At 1990s, the concept of MES was firstly gave out by Advanced Manufacturing Research of American (short of AMR), which got widely acceptance. In this concept AMR advocates using 3rd layer model to describe enterprises' information system, and the middle execution layer is called MES (Swanton 1998).

After that, many organizations recognized the necessity to give more definite definition to MES. MESA and ISA both developed related model and did great job to make it standardization. The 1990s can be called the mature phrase of MES, during this period, traditional MES developed into I-MES (integrated MES) and MES-II (Manufacturing Execution Solutions), especially at 1998, AMR put forward PEPAC model, and in this model planning, technical scheme, scheduling, execution and control integrate together.

Till now, MES has been accepted as one integrated operation system of enterprise, integrating horizontal departments, longitudinal departments and information. Because it can provide enterprises a manufacturing environment, characterized by quick response, full of elasticity and refinement, so its application scope is becoming more and more widely.

The application and study level of MES in oversea is higher than that of China. In order to satisfy the demands of customer-oriented manufacturing environment, now the MES is developing toward the following direction: (1) special MES that suits different manufacturing environment; (2) MES that can be integrated, for example NIIP-SMART which suits to virtual enterprises (Qiu et al. 2003); (3) MES oriented to mass customization (PABADIS, IST-1999-60016); (4) distributed MES (Huang 2002) and (5) web-based collaborative MES.

The application of MES in China began at 1980 and BAOSTEEL was the first company applying MES. The National 863 Plan of China listed MES as one of the key financial assistant fields, so some application and research achievements turned up gradually. Cao (Cao and Wang 2002) gave out one implementation method of MES based on CORBA model. Liu (Liu et al. 2005) studied the agile quality control system in MES. Pointed to the complex information in MES, Li (Li and Shan 2007) did systematic study and put forward four universal strategies. Hao (Hao et al. 2008) studied the structure design of MES as well as its application in dyeing industry. Pointed to the characters of smelting enterprises, Wang et al. (2011) analyzed and designed related MES system for smelting enterprises.

Overall, the study of MES in China starts relatively late, so related study mainly stays on its concept level or its single aspect technology, and in application process much more emphasis is put on software development and system modeling. The study about its practical project application and systematic application effect evaluation is lack.

19.2 Application Situation of MES in Jie Fang Company

New base of Jie Fang Company, possessing production capacity of 1,00,000 complete vehicles, locates on west of original plant site of FAW. After 2-year construction, the new site gone into production at 2005. This means the production and manufacturing level of Jie Fang steps into a new stage, but with the business development, the launch time of new products becomes shorter and shorter, meanwhile, the kinds of automobile become much more than before, so under such background the traditional handwork management way cannot satisfy the fast changing demands of market, the disjunction of between production schedule and production process control becomes more and more serious. This situation demands Jie Fang Company to introduce new management concept and new management tool, so in order to upgrade management level and satisfy the demands of market competition, application of MES becomes the best choice of Jie Fang, aiming to construct advanced information management platform and upgrade management efficiency.

At 2005, Jie Fang Company began to introduce MES as well as other information systems. Generally speaking, the application scale of MES in Jie Fang new site includes assemble workshop, frame work shop, painting plant of driver cabinets, interior decoration workshop and welding workshop of driver cabinets. The MES of Jie Fang aims to realize the following functions, including production data acquisition, production process management, production indication function, start-stop function of production line, control and feedback of automation equipment, tracking of commercial car, entrance guard management etc. All these functions are realized by the following modules, see Fig. 19.1.

Through the implementation of MES, the traditional way of manually compiling plan is replaced by system generation, complete vehicle can be controlled both on line and go off line, the production state realizes visual management, the production and quality file is set up, and the majority of materials get orderly control.

But how to quantify MES implementation effect of Jie Fang, whether the MES implementation effect of Jie Fang reach the degree described in foreign documents and what is the weak point in implementation, needing to improve urgently. All these questions need to be answered, so this paper sets up proper index system and gives out feasible evaluation method to analyze MES's implementation effect in Jie Fang Company.

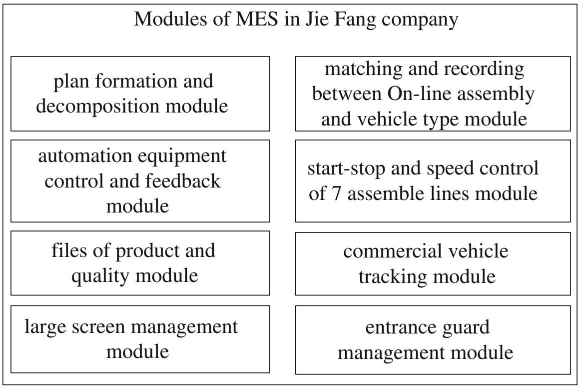

Fig. 19.1 Modules frame of MES in Jie Fang

19.3 Appraisal Index System and Method

19.3.1 Construction of Appraisal Index System

In order to evaluate implementation effect of MES scientifically, we need to know what influences MES can bring to enterprises. Some organizations have done related work, for example, MESA did two surveys about MES's implementation situation, which covers automotive industry, medical product industry, electronic industry, metal manufacturing, glass fiber industry, communication industry, synthetic resin and plastic industry. The result showed that application of MES can reduce production cycle time, lower WIP, decrease production lead time and improve product quality etc. (Li 2004). Wang and Ou Yang (2010) set up performance evaluation index system of MES for electric manufacturing industry, the indexes of this system cover three aspects, including technology indexes, financial indexes and management effect indexes. Based on value chain theory, He (2011) set up appraisal system of MES, which included project process, system application, system utility and supporting of organization. Based on extant research documents, and communicating with experts, this paper sets up implementation evaluation index system of MES for Jie Fang Corporation, see Fig. 19.2.

19.3.2 Appraisal Method

In the appraisal process of MES's implementation effect, lots of data and information can not be fixed accurately and meanwhile the appraisal is affected by many factors, so fuzzy appraisal model is feasible. As we know, membership degree conversion is the core of fuzzy evaluation model, but in the common fuzzy algorithm $M(\bullet, +)$, the values of index membership degree that have no influence

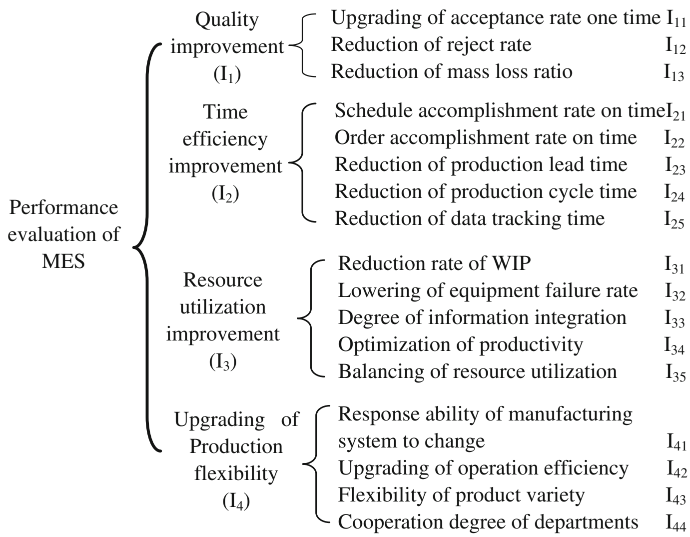

Fig. 19.2 Index system of MES implementation effect

on object classification also are used to compute the membership degree of target, so it is unreasonable. To solve this problem, in this paper a new algorithm of member conversion is applied, which is membership conversion algorithm based on $M(1, 2, 3)$. This algorithm is put forward by famous uncertain information processing expert Liu Kai-di at 2009. The main procedures of $M(1, 2, 3)$ are as follow (Liu et al. 2009; Cao et al. 2010a, b).

Firstly, fixation of classification weight

Suppose the state of target Q is affected by m indexes, and $\beta_j(Q)$ the importance weight of index j to target Q is known, satisfying $0 \le \beta_j(Q) \le 1, \sum_{j=1}^{m} \beta_j(Q) = 1$. Under each index there p ranks, C_k denotes rank $k \in (1, 2, \ldots, p)$ and rank C_k is better than C_{k+1}. If membership degree of index j to rank C_k, denoted by $\mu_{jk}(Q)$, is known and satisfying $0 \le \mu_{jk}(Q) \le 1, \sum_{k=1}^{p} \mu_{jk}(Q) = 1\ (j = 1, \ldots, m)$, then with these conditions to compute the membership degree $\mu_{jk}(Q)$, there are following situations.

If $\mu_{j1}(Q) = \mu_{j2}(Q) = \cdots = \mu_{jp}(Q)$, then from index j the degree of target Q belongs to every rank is equal, so deleting index j has no influence to the classification of target Q. If $\alpha_j(Q)$ is used to denote the contribution of index j to classification of target Q, then we can know under such situation $\alpha_j(Q) = 0$.

If there is an integer k, making $\mu_{jk}(Q) = 1$ and membership degrees of other indexes equal to 0, then the information provided by index j is that target Q only belongs to rank C_k. In this case, index j has biggest influence to classification of target Q, so $\alpha_j(Q)$ gets maximal value.

So we can say the more centralized the membership degree $\mu_{jk}(Q)$ to rank C_k, the bigger the contribution of index j to classification of target Q, which means the bigger the $\alpha_j(Q)$ is. Conversely, the less the $\alpha_j(Q)$ is.

From the introduction above, it is easy to see that $\alpha_j(Q)$, which reflects classification contribution of index j to target Q, is decided by centralization and decentralization degree of $\mu_{jk}(Q)$. While the centralization and decentralization degree of $\mu_{jk}(Q)$ can be described quantitatively by membership degree's entropy $H_j(Q)$, so $\alpha_j(Q)$ can be expressed by function of $H_j(Q)$ as follow.

$$H_j(Q) = -\sum_{k=1}^{p} \mu_{jk}(Q) \cdot \lg\mu_{jk}(Q) \tag{19.1}$$

$$v_j(Q) = 1 - \frac{1}{\lg P} H_j(Q) \tag{19.2}$$

$$\alpha_j(Q) = v_j(Q) \Big/ \sum_{t=1}^{m} v_t(Q) \quad (j = 1, 2, \ldots, m) \tag{19.3}$$

The real number $\alpha_j(Q)$ got from Formulae (19.1–19.3) is named classification weight. Obviously, it satisfies $0 \le \alpha_j(Q) \le 1; \sum_{j=1}^{m} \alpha_j(Q) = 1$. Classification weight's function lies in judging whether membership degree of index j can differentiate ranks target Q belonging to and at what degree.

Secondly, fixation of Effective value

If $\mu_{jk}(Q)(k = 1, 2, \ldots, p; j = 1, 2, \ldots, m)$ is the membership degree of index j belongs to rank C_k and $\alpha_j(Q)$ is the classification weight of index j to target Q, then the value got from following formula

$$\alpha_j(Q) \cdot \mu_{jk}(Q) \quad (k = 1, 2, \ldots, p) \tag{19.4}$$

This value is named the effective discernibility value of membership degree of index j to rank C_k or called effective value of rank k for short.

Thirdly, comparable value and membership degree conversion

In order to make the effective value of rank k to be comparable, the importance weights of indexes should be considered. If $\alpha_j(Q) \cdot \mu_{jk}(Q)$ is the effective value of index j to rank C_k and $\beta_j(Q)$ is the importance weight of index j to target Q, then the value got from following formula

$$\beta_j(Q)\alpha_j(Q) \cdot \mu_{jk}(Q) \quad (k = 1, 2, \ldots, p;\ j = 1, 2, \ldots, m) \tag{19.5}$$

This value is the comparable effective value of index j's membership degree to rank C_k or called comparable value of rank C_k. On this base, the comparable value of target Q can be got using Formula (19.6).

$$M_k(Q) = \sum_{j=1}^{m} \beta_j(Q)\alpha_j(Q) \cdot \mu_{jk}(Q) \cdot M_k(Q) \tag{19.6}$$

$M_k(Q)$ is named as the sum of comparable value of target Q to rank C_k. Obviously, bigger $M_k(Q)$ means bigger degree of target Q belonging to C_k. Suppose $\mu_k(Q)$ is the membership degree of target Q to rank C_k, it can be got through Formula (19.7).

$$\mu_k(\mathrm{Q}) = M_k(\mathrm{Q}) \Big/ \sum_{t=1}^{p} M_t(\mathrm{Q}) \quad k = 1, 2, \ldots, p \tag{19.7}$$

Till now the conversion of indexes' membership degree to target membership degree is realized. The new algorithm neither increase priori knowledge nor increase any information distortion, thus making the appraisal result more scientific.

19.4 Empirical Analysis

By consideration the practical situation of Jie Fang Company as well as the knowledge of experts, the related data is listed in Table 19.1. The importance weights in the table is got by AHP, and under every index there are four level rank, gave out based on the investigation result of MESA (Li 2004), meaning good, relatively good, general, and bad respectively. To every rank the segmentation point is gave out. The membership degree vector of second level indexes is got by linear membership function and listed in the last column. On the base of Table 19.1, this paper uses the algorithm introduced above to evaluate MES implementation effect of Jie Fang Company.

This paper takes index I_1 as an example to show the calculation process of new membership conversion algorithm. From Table 19.1, we know the membership degree matrix of the three second level indexes under I_1 is

$$\begin{bmatrix} 0.5 & 0.5 & 0 & 0 \\ 0.6 & 0.4 & 0 & 0 \\ 0.67 & 0.33 & 0 & 0 \end{bmatrix}$$

Based on Formulae (19.1–19.3), the classification weight vector of the three second level indexes is (0.3211, 0.3305, 0.3484), at the same time form Table 19.1 the importance weight of the three indexes is (0.284, 0.346, 0.370), so the comparable value matrix of I_{2j} can be got:

$$\begin{bmatrix} 0.0456 & 0.0456 & 0 & 0 \\ 0.0686 & 0.0457 & 0 & 0 \\ 0.0864 & 0.0425 & 0 & 0 \end{bmatrix}$$

Then the vector of comparable value sum of I_1 is got (0.2006, 0.1338, 0, 0), so membership degree vector of I_1 under new algorithm can be got through Formula (19.7), which is (0.5999, 0.4001, 0, 0).

Table 19.1 Related data of MES implementation in Jie Fang Company

Indexes		Importance weight	Segmentation point of 4 level ranks	Measurement value	Vector of fuzzy membership degree
I_1 (0.231)	I_{11}	0.284	(16 %, 12 %, 8 %, 4 %)	14 %	(0.5, 0.5, 0, 0)
	I_{12}	0.346	(20 %, 15 %, 10 %, 5 %)	18 %	(0.6, 0.4, 0, 0)
	I_{13}	0.370	(1.5 %, 1.2 %, 0.9 %, 0.6 %)	1.4 %	(0.67, 0.33, 0, 0)
I_2 (0.291)	I_{21}	0.276	(25 %, 20 %, 15 %, 10 %)	20 %	(0, 1, 0, 0)
	I_{22}	0.211	(20 %, 15 %, 10 %, 5 %)	12 %	(0, 0.4, 0.6, 0)
	I_{23}	0.202	(30 %, 25 %, 20 %, 15 %)	26 %	(0.2, 0.8, 0, 0)
	I_{24}	0.181	(50 %, 40 %, 30 %, 20 %)	30 %	(0, 0, 1, 0)
	I_{25}	0.131	(40 %, 30 %, 20 %, 10 %)	37 %	(0.7, 0.3, 0, 0)
I_3 (0.266)	I_{31}	0.244	(40 %, 30 %, 20 %, 10 %)	28 %	(0, 0.8, 0.2, 0)
	I_{32}	0.145	(25 %, 20 %, 15 %, 10 %)	22 %	(0, 0.4, 0.6, 0)
	I_{33}	0.186	(90, 80, 70, 60)	82	(0.2, 0.8, 0, 0)
	I_{34}	0.262	(90, 80, 70, 60)	81	(0.1, 0.9, 0, 0)
	I_{35}	0.163	(25 %, 20 %, 15 %, 10 %)	18 %	(0, 0.6, 0.4, 0)
I_4 (0.212)	I_{41}	0.321	(90, 80, 70, 60)	77	(0, 0.7, 0.3, 0)
	I_{42}	0.257	(20 %, 15 %, 10 %, 5 %)	12 %	(0, 0.4, 0.6, 0)
	I_{43}	0.198	(90, 80, 70, 60)	68	(0, 0, 0.8, 0.2)
	I_{44}	0.224	(90, 80, 70, 60)	72	(0, 0.2, 0.8, 0)

By the same way, the membership degree vector of I_2, I_3 and I_4 under new membership conversion algorithm can be got, and they compose MES's implementation appraisal matrix of Jie Fang Company,

$$\mu(\mathrm{Q}) = \begin{bmatrix} 0.5999 & 0.4001 & 0 & 0 \\ 0.1005 & 0.579 & 0.3205 & 0 \\ 0.0692 & 0.7581 & 0.1727 & 0 \\ 0 & 0.3581 & 0.5987 & 0.0432 \end{bmatrix}$$

By same logic, the comprehensive membership degree vector of target to every rank can be got that is (0.2066, 0.5398, 0.2449, 0.0087).

Because the ranks of implementation effect of MES is ordered, which means C_k is better than C_{k+1}, so the maximum membership principle, which suits disordered principle, is no longer fitted. In this paper, the confidence recognition principle is applied, suppose $\lambda = 0.7$ is the degree of confidence, through following formula $K_0 = \min\left\{k \middle| \sum_{t=1}^{k} \mu_t(\mathrm{Q}) \geq \lambda,\ 1 \leq \mathrm{k} \leq 5\right\}$, the target belongs to which rank can be fixed, and its confidence degree is bigger than 0.7. As to the MES's implementation effect of Jie Fang, through calculation, we can know its implementation effect belongs to rank 2 with a confidence degree of 74.64 %.

Through appraisal, it is easy to see that the whole implementation effect MES in Jie Fang Company belongs to rank 2, which is *relatively good*. This meaning through about 7 year's application, the MES has bring much benefit to Jie Fang. Meanwhile, through matrix $\mu(Q)$, we also can know that improvement of MES on resource utilization (I_3) and quality upgrading (I_1) is significantly, both of the two aspects has reached rank 2, with confidence degree bigger than 80 %. And the improvement effect on time efficiency (I_2) and flexibility of production (I_4) is not as good as the above two aspects, especially at flexibility of production (I_4), the improvement effect on the two aspects merely reach rank 3. The appraisal result shows that in future Jie Fang Company should put much more emphasis on the two aspects by taking more feasible and effective measurements. Because only through synergistic influence can the MES bring much more improvement to Jie Fang Company.

19.5 Conclusions

This paper introduces the implementation of MES in Jie Fang Company and on the base of extant research the index system appraising implementation effect of MES is set up, then apply fuzzy model to do appraisal. In order to avoid the defect of traditional membership conversion, the new algorithm $M(1,2,3)$ is introduced. The study of this paper not only gives a comprehensive reflection to implementation of MES in Jie Fang, but also provides one appraisal platform for enterprises implementing MES, thus has theoretical and practical significance to the smooth implementation of MES in China.

But confined to time and ability, there is still some deficiencies in this paper, for example the appraisal index system does not contain financial factors, some indexes' value is graded by experts and so on, all these may affect the appraisal's reasonability, so in future much work needs to be done about this subject.

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Chapter 20
Line Balance Wall Used in Production Process: An Assembly Line as an Example

Zong-shui Wang, Yu Liu and Xiao-hui Xing

Abstract Line balance wall is a simple and easily understood method to measure a production line whether balance or not, and it is widely used in manufacturing enterprises to balance the production line. In this paper, the application of line balance wall and the way of using line balance wall to improve production efficiency have been introduced, and an assembly line of one manufacturing company has been given as an example to further show the improving effect of the application of line balance wall when it is used to improve production process in manufacturing enterprises. The meaning of this research is that introducing an effect method to production site-improvements, and line balance wall will be used more and more widely and increase the manufacturing efficiency.

Keywords Line balance wall · Production process · Welding line

20.1 Introduction

In order to maximize production efficiency with limited resources, production directors and industrial engineers usually choose the circle time of production line and design the processing technology elaborately based on their conditions. However, the companies always have different characters and the environments they survived are different, so the production line designers choose different methods to keep the production line balance and improve the production efficiency. Line balance wall is a simple and feasible method used for work-sites

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improvement and it also reduces the difficulty of improving the production site to a large extent and makes the hidden problems emerge. At last, the companies will solve the problems based on their real condition, and go after production efficiency increasing ultimately.

20.2 Concept of Line Balance Wall

Line balance wall is a tool used to analyze every station of the production line whether it's balance or not, it also shows a flat line of a single work, the cycle time for each station (including non-value added time and value-added time), and other information which used to analyze the production line in space and methods. Line balance wall is mainly used in manufacturing enterprises to balance the production line, and lots of companies have applied the same or similar methods in manufacturing procession improvements which shows line balance wall is used widely (Ma 2010). Line balance wall shows the reality of the production line in the form of histograms by a simple and intuitive way, so we can find the bottleneck stations and the bottleneck workers of the station in production process, and then look out the reasons and put forward improving plans. In addition, line balance wall method also can be used in comparing the product efficiency before and after improvement, and reach the goal of site-improvement and get higher production efficiency.

Line balance wall is easy to be used, and it simplifies the way of site-improvements. Many manufacturing enterprises have applied it to improve production site and got remarkable benefits. Therefore, it is significant to spread and study the application of line balance wall.

20.3 Configuration of the Assembly Line

20.3.1 The Station Layout and Its Function

The assembly line of the company covers about 60 m^2, 20 m long and 3 m wide, each station covers an area about 9 m^2, the specific layout of stations from left to right is station 1–7, each station has two welding guns, stations 3 and 6 has a balanced fixture (to fix the machine when it is welding), stations 1 and 7 both has a main machine transit vehicle (for handling, storing the machine), the specific layout shown in Fig. 20.1 labels and explanations are shown in Table 20.1.

The assembly line is mainly responsible for welding, drilling, inspection of the machine and so on. It has 16 workers including 1 squad leader, 1 deputy team leader (responsible for staff deployment and daily management). The assembly line consists of 7 stations from A to G. Every station has two workers who are responsible for removal, inspection, welding, cleaning, installation, sanding welding gun etc.

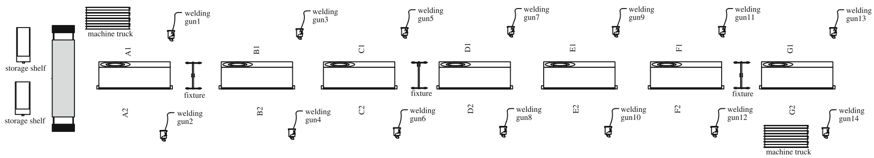
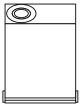
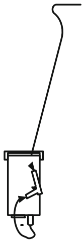
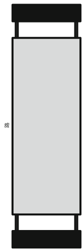
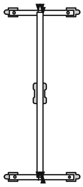
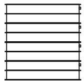
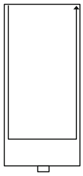


Fig. 20.1 The assembly line layout

Table 20.1 Figure explanation table

Icons							
Name	Operation desk	Welding gun	Path	Fixture	Machine truck	Storage box	Operator

20.3.2 The Cycle Time Under Current Configuration

Currently, the production line capacity is 8 machines per hour (8 JPH), through time measurement the actual production process for each beat of workers shown in Table 20.2.

Every worker 5 beats and then calculated the average data which applied in this text. Of course, when the actual process of time measuring abnormal, such as equipment maintenance, mechanical failure which resulted in production disruptions. If the measured data and the situation of normal production test results for the fluctuation range more than 10 %, this set of data as invalid.

20.4 The Application of Line Balance Wall

According to the survey that the brand of machine has a rapidly increasing market demand, if the capacity of production elevated from 8 JPH to 10 JPH the company will meet the need of market. Through line balance wall, we found the production

Table 20.2 The assembly line time record statistics of every station

Station number	1		2		3		4		5		6		7	
Worker number	A1	A2	B1	B2	C1	C2	D1	D2	E1	E2	F1	F2	G1	G2
Circle time (s)	375	375	365	365	318	318	342	342	369	369	373	373	354	354

line has potential capacity of production and we can use line balance wall to optimize the assembly line and increase the productivity without additional equipment.

The use of line balance wall consists of six parts: classification of working elements, drawing current line balance wall, finding out bottleneck stations, looking out the reasons, promoting plans of improvement, assessing after improvements. Of course, different companies have different way of the classification of operation. All the work of this paper based on the classification of this company and specific classification shown in Table 20.3.

20.4.1 Classification of Working Elements

In the manufacturing enterprise, working elements can be divided into two major categories: value-added and non-value-added, value-added work is which changed the product characteristics and increased the value of product; non-value means no change in product characteristics, but it is the essential part of production process, it can be further subdivided into walking, waiting, checking and the other.

The time of manual value added, manual non-value added, walking, waiting, other operations are abbreviated as MV(t), NMV(t), WK(t), W(t), O(t). The circle time is written as C (t) and target circle time is short of TC (t). In this paper, the relation among all working elements shown in (20.1) as follow

$$C(t) = MV(t) + NMV(t) + WK(t) + W(t) + O(t) \tag{20.1}$$

If C (t) > TC (t), it means that the company cannot meet the need of market and the production line must be optimized. In addition, the production line should be stable and the operation time of each station should be as even as possible, so as to improve the efficiency of time consuming.

Table 20.3 Detail list of working elements time measurement record

Station number	1		2		3		4		5		6		7	
Worker number	A1	A2	B1	B2	C1	C2	D1	D2	E1	E2	F1	F2	G1	G2
Manual value-added(s)	137	144	285	234	88	127	132	107	111	40	183	147	0	189
Manual non-value-added(s)	67	72	66	105	80	41	131	123	199	205	95	160	322	130
Walking(s)	171	159	14	18	85	92	79	96	60	77	54	66	23	35
Waiting(s)	0	0	0	8	65	58	0	16	0	47	31	0	9	0
The other(s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total(s)	375	375	365	365	318	318	342	342	369	369	373	373	354	354

20.4.2 Drawing Line Balance Wall

Drawing line balance wall based on the data in Table 20.4 shown as Fig. 20.2 (from left to right: A1–G1, the two adjacent columns picture shows different operators of the same station).

Black line is shown as TC (t) and on the scale of 360s; grey line is for the max{C (t)} which spends the most time under the conditions of actual production (Wang 2009). One column figure with different colors from the bottom to the top is behalf of the operation time manual value-added, manual non-value-added, walking and waiting.

20.4.3 Finding Out the Bottleneck Stations and Causes

Though analysis of Fig. 20.2 we can find that C (t) > TC (t) at station 1, 2, 5, 6 and station 1, 5, 6 are the main bottleneck stations. Through observing production-site and production process documents, we found the layout of station 1 is unreasonable, placement of storage boxes and fixtures should be simple adjusted; station 2: lots of checking time leads to C (t) > TC (t); on station 5, distribution of job content is not even which results in plenty of waiting time; Similarly, station 6, staff F1 has to wait for F2, while F2's working time is over the circle time, the reason is that staff F2 has to handle a huge fixture by himself and it is difficult to be located.

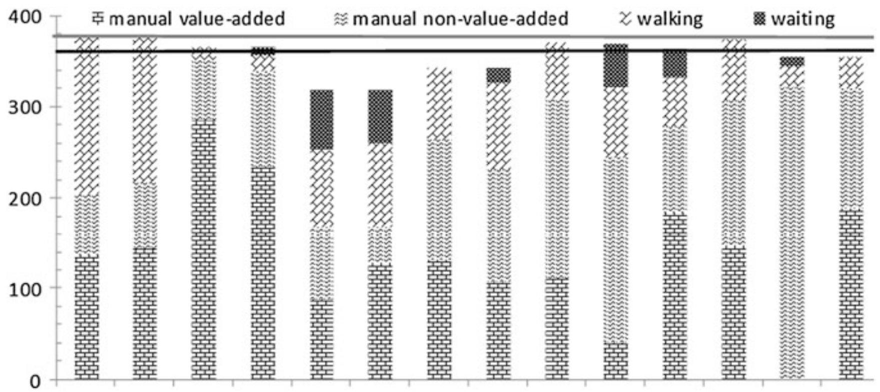


Fig. 20.2 Line balance wall before improvement

20.4.4 Site-Improvements to Eliminate Bottlenecks

(1) *Adjusting the station layout to reduce unnecessary movements*
Reasonable adjustments to station layout are important way to improve the production-site and then we can increase productivity without additional personnel and equipment (Yao 2009). We change the layout of positions 1 and 2 shown in Fig. 20.3.
Before improving, there is lots of walking on station 1 as shown in Fig. 20.3 (left) Yao (2009). The machine must be moved to station 2 after welding, while in the movement, the workers have to turn around the fixture and then back to storage boxes and then bring left and right shelves to operation desk. So we change the layout of station 1 and 2 shown as Fig. 20.3 (right), we can reduce the walking time of moving the machine and reduce the distance between storage boxes and operation desk. Though calculation we can reduce 24–25 walking steps when the machine is processed, so we can save 17–18 s, and reach the goal of 10 JPH.

(2) *Eliminating the waiting time*
Line balance wall shows that E1 and E2's production time surpassed the target cycle time, if we eliminate the waiting time of E2, CT (t) will be less than TC (t), so E2 is not the bottleneck operator. Through scene observation, we found the worker E1 has to do lots of checking work, while E2 has to wait for him, so we add some work of checking to E2 based on time measurement analysis and technical requirements. In addition, position 6 has the same problem: F1 has to handle a large and heavy fixture alone, it is difficult and time-consuming, so we arrange F2 to help F1 handling and positioning the fixture which can reduce F1's operating time and eliminate F2's waiting time.

(3) *Reconstruction of work*
Reconstruction of operations includes rearrangements of single station and the whole production line (Wu and Xu 2008), but actual reconstruction should be based on production-site and technical requirements. For example, we leave station 2's checking work to station 3 which reduces the waiting time of station 3 and also promote the whole line's productivity, of course this adjustment should be in condition of station 3's workers must have a good knowledge of station 2's technical requirements or it will cause bad influence.

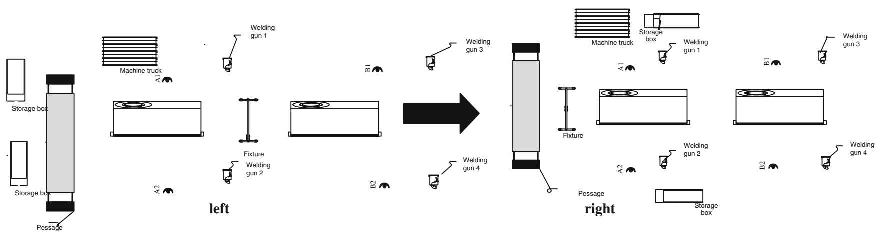


Fig. 20.3 Station layout comparison before and after adjustment

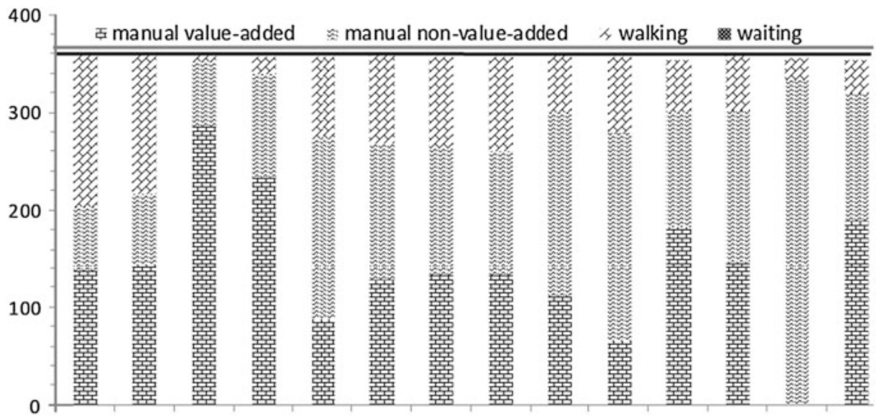


Fig. 20.4 Line balance wall after improvement

20.4.5 Assessment After Improvements

(1) *Drawing new line balance wall*
According to the improvements of (c) and (d), we draw the expected line balance wall shown in Fig. 20.4.
(2) *Production conditions comparison before and after improvement*
By comparing Figs. 20.2 and 20.4, it is easy to find the production time is under the red line which indicated that C (t) $\leq$ TC (t) meant the entire production line has eliminated the bottlenecks and achieved the 10 JPH requirements, as well as eliminated waiting time, unreasonable layout and promoted workers' productive efficiency.

20.5 Conclusion

In this paper, we selected an assembly line of a manufacturing company as an example to study the application of line balance wall. Line balance wall simplifies the process of site-improvements, makes the unreasonable production process come out, and provides a convenient way to site-improvements. Line balance will be wildly used in site-improvements.

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Chapter 21
Performance Analysis for a Repair System with Double Interchangeable Components Under Precedence Constraints

Xiao-bin Li, Bin-feng Li, Kai Tian and Su Wu

Abstract This paper presents an analytical continuous-time Markov chain approach for modeling a repair system with interchangeable components in resources allocation. As an important type of a repair-service system, a repair system with interchangeable components features the components which are assembled circularly with interchangeable-component inventories after a piece of equipment is disassembled. Despite the improved efficiency, major difficulties in model formulating and performance analyzing arise due to the complex fork/join structure and the particular existence of interchangeable component inventories. In this paper, a continuous-time Markov chain stochastic model is developed with a repair system with double interchangeable components under precedence constraints. The stationary distributions are then attained with programming and the performance analysis follows with numerical experiments. Particularly the relationship between the key resources and the performance indicators is studied to provide a strategy of resource allocation.

Keywords Continuous-time Markov chain · Fork/join queue · Performance analysis · Precedence constraints · Repair system with double interchangeable components

21.1 Introduction

For many large-scale manufacturing and logistics systems, such as aerospace, aviation, railway and so on, the repair services with interchangeable components hold the core domain in maintenance industries.

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In this interchangeable-component system, the usage of extra stored components for interchange greatly reduces the delay of assembly problem for original combination. And as the advantage of interchangeable components recycling, 53 billion dollars are saved within maintenance services in United States Ni et al. (2004). However, there are challenges for the implementation of repair systems with interchangeable components because the unbalanced resource allocation leads to various conflicts, for example, the shortage or the waste of key resources in the process.

In the past decade, the interest of researchers has grown on the repair systems with interchangeable components on maintenance services of large scale facilities. From 1996 to 2000, V. D. R. Guide (Becker and Szczerbicka 1998, 2001; Dallery et al. 1997; Guide 1996, 2000) presents series of papers about production planning and control by discrete simulation, to consider repair systems with interchangeable components systematically. Following the method of discrete treatments and operations research, many experts have extended the scope of researches. In 2004, Ni et al. (2004) use linear stochastic model with dynamic programming algorithm in the inventory control policy for maintenance networks. Luh et al. (2005) continued the study to schedule asset overhaul and repair services by a Lagrangian relaxation based approach. In particular, continuous-time on stochastic model is mentioned seldom in the latest studies. Tu et al. (2003) have developed model reduction for fork/join overhaul and repair systems with interchangeable inventory on turn-around time, but only proposed the approximate second order presentation due to the complex logical construction.

Despite the variety of the available methods presented in the literature, fork-join queue network with blocking (FJQN/B) approximates to the repair system structure with interchangeable components. FJQN/B is constituted of the server set and buffer set, and only single buffer exists between the neighbor servers, with infinite buffer size. Kim and Agrawala (1989), Liu and Perros (1991), Thomasian and Tantawi (1994) develop the solution methods on distinct model assumption, like ignoring the fork-join operating time, deterministic time of fork-join operating, or blocking relaxation. Dallery et al. (1997) presents the mathematical norm upon FJQN/B, and analyze the properties of fork/join queueing networks with blocking under various operating mechanisms. Apon and Dowdy (1997) resolves the models of parallel systems based on a circulating processor model, which tend to be computationally complex due to synchronization constraints such as task forking and joining. Becker and Szczerbicka (1998, 2001) integrates the multi-class queueing networks with generalized stochastic Petri Nets—PNiQ (Petri Nets including Queueing Nets), and combines the advantages of two methods.

As there has been little work in the research of the performance of the repair system with interchangeable components, it is difficult to evaluate and optimize the system performance in the early stage. And in particular, Markov method with the continuous-time treatment is seldom mentioned in the latest research reports on the systematic level with interchangeable components. The continuous-time Markov chain, with the exact solutions of the system states, is applied as a stochastic process approach to base the performance numerical cases upon.

The research is developed in a step-by-step manner on the performance of this repair system in this paper. The algorithm of continuous-time Markov chain is used to build the mathematical models in Sect. 2. In Sect. 3, the performance of the repair system with double interchangeable components under precedence constraints is studied by numerical experiments, which focus on the relationships with two kinds of resource allocation problems, including allocation of stations, and the operating rate. Three performance indicators, including the throughput, work in process and the utilization are analyzed on the above problems for the system performance. Finally, the complexity of this double-component system is presented in Sect. 4 as well.

21.2 Continuous-Time Markov Chain Model

21.2.1 Problem Description

The characteristics of the repair system with interchangeable components are demonstrated in two aspects by comparison to the normal repair system:

(1) Resources of the system. The repair system with interchangeable components covers two major resources: the inventory and the fixed stations. For the smooth and efficient function of this system, some interchangeable components are purchased for stores in advance to avoid the delay of an operating schedule under the production fluctuation. With respect to the high expenditure on interchangeable components, the size of inventory is around several units generally. Additionally as a result of the wide application for large-scale logistics equipments, a fixed station mode is commonly adopted in the facilities installation.
(2) Structure of the system. Firstly, precedence relations exist in the fork-join process, so that the operations are required to follow the job settings. Secondly, as a typical case of Markov chain, the fork-station is to proceed only in the blocking status but with no starving, on the contrary to both join-station and repair-station. Thirdly, the system capacity has an upper limit correspondingly with the size of stations and inventories.

The equipment is forked apart as a perfect SNS (Serial Number Specific, the non-interchangeable part of the equipment) and damaged interchangeable components. On condition that there exists both available join-station and available interchangeable components at the inventory buffer, the separate SNS and anyone of these components at the inventory buffer would be joined as a new piece of equipment. In case that no interchangeable components are available at the inventory buffer, the SNS has access to the join-station in a waiting status. If all join-stations are occupied, the SNS holds on at the fork-station. Meantime, the separate damaged interchangeable component will get into the inventory buffer

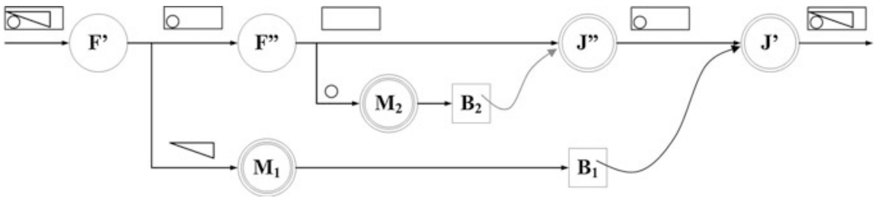

Fig. 21.1 Repair system with double interchangeable components under precedence constraints

after a repair-operation, waiting to be joined with an SNS by the *First Come First Serve* (FCFS) policy.

The system with double interchangeable components under precedence constraints is shown in Fig. 21.1. The whole equipment is disassembled on fork stations with two kinds of components apart in a job-setting sequence; these two kinds of damaged components are repaired respectively before the join-operation; and the join-operation setting sequence is required for two kinds of separate components until the equipment completes the entire procedures.

What needs to be emphasized is that the fork-operations of two kinds of interchangeable components are performed on an identical station as well as the join-operations. The presentation of F′ and F″ as shown in Fig. 21.1 is demonstrated only for the illustration of the job settings.

21.2.2 Notations

f	number of fork-stations at F-zone (F′ and F″)
j	number of join-stations at J-zone (J′ and J″)
m_1	number of repair-stations at M_1
m_2	number of repair-stations at M_2
i_1	number of interchangeable components at the inventory buffer B_1
i_2	number of interchangeable components at B_2
$F'(t)$	number of operating fork-stations with components I
$F''(t)$	number of operating fork-stations with components II
$J''_0(t)$	number of SNSs at J″, including the joining ones and the awaiting ones
$J''_2(t)$	number of components II at J″, including the joining ones and the awaiting ones
$J'_{02}(t)$	number of semi-equipments at J′, including the joining ones and the awaiting ones
$J'_1(t)$	number of components I at J′, including the joining ones and the awaiting ones
$M_1(t)$	number of components I at M_1, including the repairing ones and the awaiting ones
$B_1(t)$	number of components I at B_1

$M_2(t)$ number of components II at M_2, including the repairing ones and the awaiting ones
$B_2(t)$ number of components II at B_2

21.2.3 Mathematical Model

Note that the Markov state of the repair system with double interchangeable components could be defined as $X^{**}(t) = \{F'(t), F''(t), J_0''(t), J_2''(t), J_{02}'(t), J_1'(t), M_1(t), B_1(t), M_2(t), B_2(t)\},\ t \geq 0$ and the state space as

$$S^{**} = \{X^{**}(t)\},\ t \geq 0$$

The system state contains ten dimensions with min$\{J_0''(t), J_2''(t)\}$ representing the number of the joining SNS and the joining component I, min$\{J_{02}'(t), J_1'(t)\}$ representing the number of the joining semi-equipment and the joining component I, min$\{M_1(t), m_1\}$ representing the number of the repairing component I, and min$\{M_2(t), m_2\}$ representing the number of the repairing component II. The stochastic variables F', F'', J_0'', J_2'', J_{02}', J_1', M_1, B_1, M_2, B_2 are denoted in brief.

The assumptions are shown as follows,

(1) Each piece of equipments is constituted of one perfect SNS, one damaged component I and one damaged component II;
(2) Infinite input;
(3) Precedence constraints exist. The fork-operation of component I should be precedent with that of component II and the join-operation of component II should be precedent with that of component I.
(4) Operating time (forking time, joining time and two types of repairing time) follows the i.i.d. exponential distribution with parameters μ_F, μ_J, μ_{M1}, μ_{M2};
(5) Fork-stations F′ and F″ perform the identical operating rate μ_F;
(6) Join-stations J′ and J″ perform the identical operating rate μ_J;
(7) Simultaneous unloading policy is performed on F-zone (F′, F″);
(8) Independent loading policy is performed on J-zone (J′, J″);
(9) Buffer with blocking-after-service is performed on M-zone (M_1, M_2);
(10) Inventory buffer B_1, B_2 contain certain number of the interchangeable components I and II i_1, i_2 in advance;
(11) No capacity limit at both M-zone (M_1, M_2) and inventory buffer (B_1, B_2).

For this repair system with double interchangeable components under precedence constraints, the model constraints are required as follows:

$$F' + F'' \leq f \tag{21.1}$$

$$J_0'' + J_{02}' \leq j \tag{21.2}$$

$$J_1 \leq j \tag{21.3}$$

$$J_2'' + J_{02}' \leq j \tag{21.4}$$

$$f + J_0'' + J_{02}' = F' + M_1 + B_1 + J_1' - i_1 = F' + F'' + M_2 + B_2 + J_2'' + J_{02}' - i_2 \tag{21.5}$$

$$if\ J_0'' + J_{02}' < j,\ then\ F' + F'' = f \tag{21.6}$$

$$if\ J_1' < j,\ then\, B_1 = 0 \tag{21.7}$$

$$if\ J_2'' + J_{02}' < j,\ then\ B_2 = 0 \tag{21.8}$$

$$F'', F', J_{02}', J_0'', J_1', B_1, M_1, J_2'', B_2, M_2\ are\ nonnegative\ \text{int}egers \tag{21.9}$$

Define the number of CTMC states as $Card(S^{**}) = k$, namely the system could possess k stationary states.

The stationary distribution $\pi = (\pi_1, \ldots, \pi_k)$could be derived from $\pi \cdot T = 0$, $\pi \cdot e = 1$.

21.3 Performance Analysis Of Double-Component System Under Precedence Constraints

21.3.1 Formulation of Indicators

System performance is our interest to be focused on by the common measures widely adopted in the production systems, such as the throughput, work in process (*WIP*) and the utilization of the implements.

Based on the stationary distribution π derived from the Markov model, the three performance indicators in the repair system with double interchangeable components are formulated as,

Throughput

$$TP = \mu_{J'} \cdot \sum_b \min(J_{02b}', J_{1b}') \cdot \pi_b \qquad b = 1, \ldots, k$$

Work in process

$$WIP = f + \sum_b (J_{0b}'' + J_{02b}') \cdot \pi_b$$

Utilization of Fork-station

$$U_F = \sum_b (F_b' + F_b'') \cdot \pi_b / f$$

Utilization of Join-station

$$U_J = \sum_b [\min(J''_{0b}, J''_{2b}) + \min(J'_{02b}, J'_{1b})] \cdot \pi_b / j$$

Utilization of Repair-station M_1

$$U_{M1} = \sum_b \min(M_{1b}, m_1) \cdot \pi_b / m_1$$

Utilization of Repair-station M_2

$$U_{M2} = \sum_b \min(M_{2b}, m_2) \cdot \pi_b / m_2$$

21.3.2 Performance on Station Allocation

In a deterministic model of production systems, the scale of operating station is inversely proportional with the operating time in order to balance the product flow. In this section the numerical experiments are carried out to discover the influence of the throughput (*TP*) on the allocation of four kinds of stations *f*, *j*, m_1, m_2 at a fixed station scale and incremental inventory level, aiming to attain the optimal allocation with the maximum throughput. The values of the model parameters are originated from the real production system.

Because the operating time follows exponential distribution with the same value of expectation and standard deviation, i.e. when the operating time with the larger deviation is longer, the allocation under the inverse proportion (IP) would not be the optimal solution. In the stochastic model of resources allocation, inverse proportion is also one part of our experiments where the TP_{pro} stands for the throughput under this IP relationship in order to inspect its applicability (Table 21.1).

The substitutes of parameters for Experiments 1 and 2 are

$$\left(\frac{1}{\mu_{F'}} + \frac{1}{\mu_{F''}}\right) : \left(\frac{1}{\mu_{J'}} + \frac{1}{\mu_{J''}}\right) : \frac{1}{\mu_{M1}} : \frac{1}{\mu_{M2}} = 1:5:1:1$$

$$\left(\frac{1}{\mu_{F'}} + \frac{1}{\mu_{F''}}\right) : \left(\frac{1}{\mu_{J'}} + \frac{1}{\mu_{J''}}\right) : \frac{1}{\mu_{M1}} : \frac{1}{\mu_{M2}} = 1:6:1:1$$

Table 21.1 Numerical experiments on station allocation

No.	Parameters values		Allocation under IP
1	$f + j + m_1 + m_2 = 8$ $i_1 = i_2 = 0{:}18 = i$	$\mu_{F'} = \mu_{F''} = 10$, $\mu_{J'} = \mu_{J''} = 2$, $\mu_{M1} = \mu_{M2} = 5$	$f = m_1 = m_2 = 1$, $j = 5$
2	$f + j + m_1 + m_2 = 9$ $i_1 = i_2 = 0{:}18 = i$	$\mu_{F'} = \mu_{F''} = 6$, $\mu_{J'} = \mu_{J''} = 1$, $\mu_{M1} = \mu_{M2} = 3$	$f = m_1 = m_2 = 1$, $j = 6$

Table 21.2 Numerical results of experiment 1

i	Optimal allocation (TP_{max})					Allocation under IP (TP_{pro}: $f = m_1 = m_2 = 1, j = 5$)		
	f	j	m_1	m_2	TP	TP	Increase (%)	Gap of TP_{max} and TP_{pro} (%)
0	2	4	1	1	3.348	3.331	–	0.51
1	–	–	–	–	–	3.564	6.99	–
2	–	–	–	–	–	3.718	4.32	–

Table 21.3 Numerical results of experiment 2

i	Optimal allocation (TP_{max})					Allocation under IP (TP_{pro}: $f = m_1 = m_2 = 1, j = 6$)		
	f	j	m_1	m_2	TP	TP	Increase (%)	Gap of TP_{max} and TP_{pro} (%)
0	2	5	1	1	2.094	2.057	–	1.73
1	2	5	1	1	2.202	2.182	6.07	0.91
2	2	5	1	1	2.275	2.266	3.84	0.42
3	2	5	1	1	2.332	2.322	2.45	0.45

The numerical results of Experiments 1 and 2 are shown in Tables 21.2 and 21.3.

The conclusions are drawn as follows:

(1) The resources allocation under inverse proportion (IP) with the operating time is not the optimal allocation in stochastic conditions.
(2) The number of the station with high operating rate in optimal allocation is more than that in the allocation under IP, while the opposite happens with the station with low operating rate (see f and J in Exp. 1 and 2).
(3) With the inventory scale increasing, the optimal allocation adjusts toward the allocation under IP and the gap between TP_{max} and TP_{pro} follows a process of closer then bigger (Exp. 2). It illustrates that the inventory could reduce the gap between the two kinds of allocation at a certain stage.
(4) TP keeps rising with the inventory scale increasing (normal repair system when $i = 0$), but the marginal utility of rising is decreasing gradually.

21.3.3 Performance on Operating Rate

In order to examine the effect of operating rate on system performance, Experiments 3–7 (see Table 21.4) are implemented with incremental operating rate where the calculated results are shown in Fig. 21.2.

The numerical results of Experiments 3–7 are shown in Fig. 21.2.

Conclusions are drawn:

Table 21.4 Numerical experiments on operating rate

No.	Parameters values	
3		$\mu_{J'} = \mu_{J''} = 20,\ \mu_{M1} = \mu_{M2} = 10,\ \mu_{F'} = \mu_{F''} = 2{:}2{:}40$
4	$j = f = m_1 = m_2 = 2$	$\mu_{F'} = \mu_{F''} = 20,\ \mu_{M1} = \mu_{M2} = 10,\ \mu_{J'} = \mu_{J''} = 2{:}2{:}40$
5	$i_1 = i_2 = 1$	$\mu_{F'} = \mu_{F''} = \mu_{J'} = \mu_{J''} = 20,\ \mu_{M2} = 10,\ \mu_{M1} = 1{:}20$
6		$\mu_{F'} = \mu_{F''} = \mu_{J'} = \mu_{J''} = 20,\ \mu_{M1} = 10,\ \mu_{M2} = 1{:}20$
7		$\mu_{F'} = \mu_{F''} = \mu_{J'} = \mu_{J''} = 20,\ \mu_{M1} = \mu_{M2} = 1{:}20$

(1) Marginal utility is displayed on the curve of $TP, U_{F,} U_{J,} U_{M1,} U_{M2}$.
(2) The increments of $\mu_j, \mu_{M1}, \mu_{M2}$ and μ_M affect the *WIP* in a weak effect. The system performance not only depends on the single operation but also the other ones, and the precedence constraints weaken the sensibility of system performance upon the only parameter.
(3) The performance upon the total repair-operating rate μ_M takes around more 5 % of utilization of other stations than that of μ_{M1} or μ_{M2}.

21.3.4 Algorithmic Complexity

Note that the formula in the set theory:

$$\begin{aligned} Card(U/(U_1 \cup U_2 \cup U_3)) = & Card(U) - Card(U_1) - Card(U_2) - Card(U_3) \\ & + Card(U_1 \cap U_2) + Card(U_1 \cap U_3) + Card(U_2 \cap U_3) \\ & - Card(U_1 \cap U_2 \cap U_3) \end{aligned}$$

The sets which fit the constraints (21.6–21.8) are defined by $U_1 - U_3$ and U for the set with the other constraints. The number of the CTMC states in the double-component system under precedence constraints is shown by the mathematical formula at the next page.

The number of states is unrelated with m_1, m_2 and defined only by f, j, i_1, i_2, Three of them are fixed 5 as a constant; in order to inspect the trend of the number of states with the only parameter valued 1–20.

In Fig. 21.3, the number of system states displays the same curves with the increments of f or j, which can be explained by the structure and mechanism of the particular repair system. And as well, the scale of the calculation is sensitive with f and j, which leads to the difficulties in solving the large scale system.

Fortunately, the properties obtained by the performance analysis of the double-component system under precedence constraints could remain in the large scale repair systems with the similar structure.

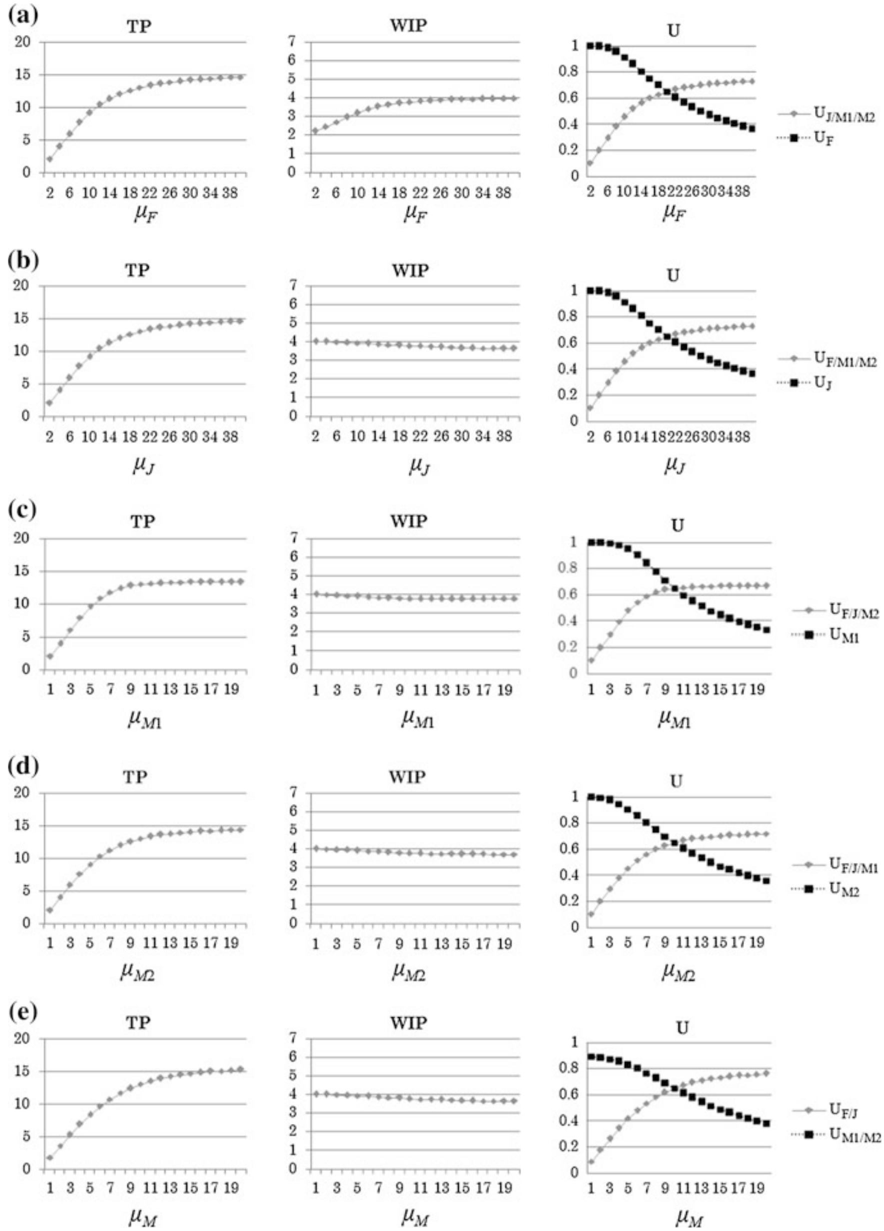

Fig. 21.2 Numerical results on operating time **a** fork-operation rate **b** join-operation rate **c** repair-operation rate for component I **d** repair-operation rate for component II **e** total repair-operation rate

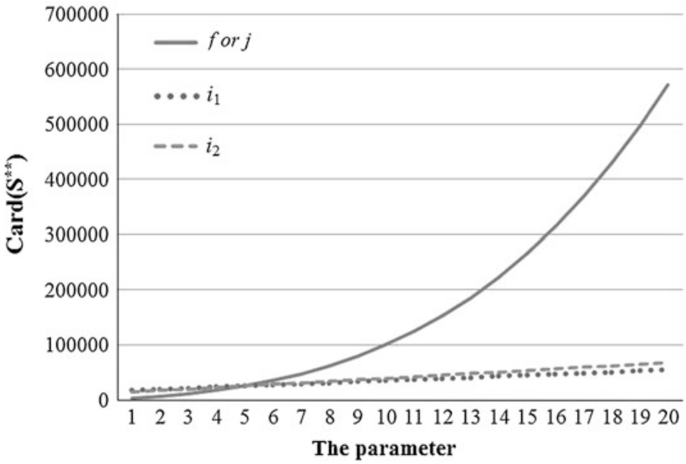

Fig. 21.3 The number of states with system parameters

21.4 Summary

For repair system with interchangeable components, the previous research seldom covered the performance of the entire system, especially the relationship between the system performance and the key resources allocation.

Marginal utility is highlighted in the cases and the allocation under inverse proportion remains a guiding strategy in allocating stations. In addition, the precedence constraints weaken the sensibility of system performance upon the only parameter.

In actual, this kind of repair system is widely implemented for large-scale logistics equipments with high expenditure on interchangeable components, and most facilities like join-stations or fork-stations keep an unchangeable construction after the initial installation. Consequently, the allocation of the key resources takes a fundamental place in priority. Actually, concerning the size of component inventories and the category of interchangeable components, the CTMC approach could settle this issue in an acceptable scale, which is supported by the explanation of algorithmic complexity. Relevant further research may cover a generalization to multi-item model which is certainly not straightforward.

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Chapter 22
Prediction of Erp Success Before the Implementation

R. Dhinakaran Samuel and Santhosh Kumar

Abstract ERP systems are capable of providing significant return on investment. Implementing these projects place tremendous demand on organization's time and resource. Unfortunately the success rate of ERP implementations is limited. Much has been written about implementation and critical success factors (CSF) but there is little effort to predict the success before starting of the implementation. The present study focuses on (1) identifying the key critical success factors which can identify the success or failure as well as that can be measured before start of the implementation.(2) Derive a prediction model using the above CSFs and using Multi variant Discriminant Analysis. (3) Develop a model to predict the time frame on which the project is expected to complete. It uses case study methodology; eight cases were studied to derive the model, four successful and four unsuccessful implementations of a same Project manager.

Keywords Assessment · Critical success factors · Enterprise resource planning · Implementation time frame

22.1 Introduction

Enterprise resource planning (ERP) packages exploded into the market during 1990s as a popular way by which companies attempted to integrate their financial, human resource, operation, and customer information. Now after a decade of

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experimentation, the key business driver for this implementation in most of the companies is 'increasing the bottom line'. They expect to achieve any one of the following business benefits.

- Provide efficiency gains that reduce overhead or allow the company to do more without adding resources,
- Put the organization in compliance with legal or contractual requirements, decreases security risk or to reach technology compatible with that of the customers,
- Support a new strategic initiative.

Unfortunately, the success rate of ERP implementations is only around 50 % and approximately 90 % of ERP implementations are late or over budget. Implementing these projects place tremendous demands on organization's time and resources. There are risks associated with this type of investments. Most of the investors burn their fingers after entering into this exercise. There is no tool available to predict the time frame of the implementation. This study attempts to bring out a model to predict this.

22.2 Review of Literature

Concepts of ERP system was first introduced in 1990 (Huang et al. 2004). Many researchers (Plant and Willcocks 2007; Chien and Tsaur 2007) worked on to identify key areas where things must be go right for the implementation to be successful. Those key areas are called Critical success factors (CSF). Twelve commonly accepted CSFs are identified by (Bhatt 2005) for the success of ERP implementation project. The key players associated with ERP implementation and stake holder analysis is detailed in (Somers and Nelson 2004; Chetcuti 2008). All ERP implementations goes through selection, implementation and post implementation phases and follow standard implementation methodology as per (Esteves and Pastor 2001; Peslak et al. 2008; Muthu et al. 1999).

ERP implementations can turn into nightmare if it is not carefully planned, also insufficient integrations between groups, processes and latest technology prevents getting the fruit of the implementation (Davenport 1998). The full potential of ERP system was not utilized in most cases, hardly 10 % achieved (Yaseen 2009). Many projects are unsuccessful, mostly due to their complexity being under estimated (Štemberger et al. 2009; Chung et al. 2009). 70 % of the large scale implementation failed (Kim 2011). The fix/upgrade schedule forced by ERP vendor make many implementations become outdated. Therefore delay in implementation schedule becomes much more costly (Olson and Zhao 2007; Fryling Un published).

Hence prediction of ERP implementation success upfront is a point of concern. These predictions enable organizations to decide whether to initiate ERP, inhibit adoption or take remedial action to increase the feasibility of successful ERP. Few researches (Fryling Un published; Lim 2006) on this area was carried out using Case based reasoning model and Artificial intelligence techniques.

22.3 Research Method

It uses case study methodology. Eight cases were identified, four successful and four unsuccessful implementation of the same project manager (First author of this article). The project manager has implemented ERP systems like SAP, JD Edwards Enterprise one, Oracle E-business suite and many custom software for more than 20 organizations in India and abroad. Many projects were successful and some were failure. Details of the chosen eight organizations are shown in Annexure: A. Data collected by conducting direct interviews at various levels of the subject organization on each of the parameters on a 10 point scale (Wu and Wu 2011; Xu 2011).

22.4 Objective of the Study

The objective of the study is to help the business community to carry out readiness assessment for an ERP implementation project by predicting upfront its success or failure and time frame for the implementation. The study has three phases.

- Identification of Key Critical success factors that can be measured before starting of the project as well as reveal the success or failure accurately (Dhinakaran Samuel 2010).
- Derivation of a prediction model using the above parameters.
- Estimation of project completion time frame based on the above data.

22.5 Results and Discussion

22.5.1 Phase 1: Identification of Key Critical Success Factors

When twelve commonly identified CSFs (Huang et al. 2004)

1. Project management
2. Business process re-engineering
3. User training and education
4. Technology Infrastructure
5. Change management

6. Management of Risk
7. Top management support
8. Effective communications
9. Team work and composition
10. User involvement
11. Use of Consultant
12. Goals and Objectives

are applied to the cases referred in this study, the analysis gives almost equal score for success and failure projects. The second author's previous study referred (Hsu et al. 2009) proves the behavior model which involves following parameters are more effective in identifying the successful project.

1. Vendor transparency
2. Top management priority
3. Positional power user involvement
4. Knowledge power user sharing
5. Project team dedication
6. Transaction user change
7. Consultant customer focus

The above seven parameters can be measured before starting of the project using structured questionnaire/direct interviews with all the seven type of people who will be involved in the project.

22.5.2 *Phase 2: Derivation of a Prediction Model*

Using the data generated from the above eight cases, a Multivariate Discriminant Analysis carried out using SPSS and details are given below: In Discriminant analysis we are trying to predict a group membership, the Group Statistics and Tests of Equality of Group shows significant differences between means of success and failure for all variables with project team dedication and consultant customer focus producing very high value F's. Here, the maximum number of discriminant functions produced is the number of groups minus 1. We are only using two groups here, namely 'success' and 'failure', so only one function is displayed. The canonical correlation is the multiple correlations between the predictors and the discriminant function. With only one function it provides an index of overall model fit which is interpreted as being the proportion of variance explained (R2). a canonical correlation of 0.997 suggests the model explains 99.993 % of the variation in the grouping variable. Wilks' lambda indicates a highly significant function ($0.021p < 0.05$) and provides the proportion of total variability not explained, i.e. it is the converse of the squared canonical correlation. So we have 0.007 % unexplained.

The interpretation of the discriminant coefficients (or weights) is like that in multiple regressions. Following are the index of the importance of each predictor like the standardized regression coefficients (betas) did in multiple regressions.

- Vendor transparency (−2.560)
- Top management priority (−6.848)
- Positional power user involvement (2.119)
- Knowledge power user sharing (3.938)
- Project team dedication (−1.097)
- Transaction user change (6.083)

The sign indicates the direction of the relationship. Transaction user change was the strongest predictor while top management priority (note −ve sign) was next in importance as a predictor. These two variables with large coefficients stand out as those that strongly predict allocation to success or failure companies. Vendor transparency, pos. Power involvement, knowledge power sharing and project team dedication were less successful as predictors. Another way of indicating the relative importance of the predictors is the structure matrix correlations and it can also be seen that the same pattern holds (Table 22.1).

These unstandardized coefficients (b) are used to create the discriminant function (equation). It operates just like a regression equation. In this case we have:

D = (−0.804 × vendor transparency) + (−4.331 × top mgt priority) + (1.754 × pos power involvement) + (3.261 × knowledge power sharing) + (−0 1.201 × project team dedication) + (5.631 × Trans user change) − 18.802

The discriminant function coefficients b or standardized form beta both indicate the partial contribution of each variable to the discriminate function controlling for all other variables in the equation. They can be used to assess each variable's unique contribution to the discriminate function and therefore provide information on the relative importance of each variable.

A further way of interpreting discriminant analysis results is to describe each group in terms of its profile, using the group means of the predictor variables. These group means are called centroids. Success has a mean of 10.379 while

Table 22.1 The canonical discriminant function coefficient table (un standardized co-efficient)

	Function 1
Vendor transparency	−0.804
Top management priority	−4.331
Positional power involvement	1.754
Knowledge power sharing	3.261
Project team dedication	−1.201
Transaction user change	5.631
(Constant)	−18.802

failure produces a mean of −10.379. Cases with scores near to a centroid are predicted as belonging to that group. Finally, there is the classification phase. The classification results reveal that 100 % of respondents were classified correctly into 'success' or 'failure' groups.

22.5.3 Phase 3: Estimation of Time Frame for the Implementation

All ERP implementations go through following three phases. Success or failure depends on the activities carried out each of the phases.

1. Selection phase where requirement finalization, ERP selection and Vendor selection takes place.
2. Implementation phase where the activities like Business Analysis, Set up/ Configuration, Conference room pilot. Customization, Production set up, Data migration, Security profile, Readiness assessment, Go live takes place.
3. Post implementation where activities like Report generations, Monthly/Yearly closing, Refinement takes place.

Time frame for ERP implementation varies for different type of implementation as well as number of modules implemented. Following are the standard implementation time frame (ST) of different type of implementation (including post implementation) based on the experience of the Second Author

1. Green filed site (GF)–7 months.
2. Roll out implementation (RO)–10 months
3. New implementations for existing company (NEW)–12 months
4. Pilot implementation for a group company (PILOT)–15 months

Based on the standard norms advocated by different ERP vendors for the implementation of existing single company, effective percentage of contribution by the seven behavior factors discussed earlier was arrived at and shown in Table 22.2

Table 22.2 Percentage of contribution by behaviour factors

Sl. no	Behavior parameters	Contribution % (BP)
1.	Vendor transparency	15
2.	Top management support	6
3.	Positional power user involvement	17
4.	Knowledge power user sharing	7
5.	Project team dedication	22
6.	Transaction user change	12
7.	Consultant's customer focus	21

Table 22.3 X' and 'C' value table

Score (S)	**X**	**C**
S > 5	10-S	20
S < 5	6-S	100

Estimation of time frame is arrived using the standard implementation time frame of different type of implementations and the delay contributed by each behavioral parameter

Estimated time (T) = Standard Time (ST) + Standard Time (ST) * Total Delay (TD)

Total Delay (TD) = Delay due to behavior parameter 1 (D1) + Delay due to behavioral parameter 2 (D2) + ········· + Delay due to behavioral parameter 7 (D7)

Whereas Delay due to behavioral parameters (D) = Behavior pattern contribution (BP) * Percentage delay (Y)

$$D = BP * Y$$

$$D1 = BP1 * Y1$$

$$D2 = BP2 * Y2$$

$$\ldots\ldots$$

$$D7 = BP7 * Y7$$

Percentage Delay $(Y) = X * C$, which depends on the score (S) obtained through Survey/Interview on each behavioral parameters (Table 22.3).

Hence $\mathbf{T} = \mathbf{ST} + \mathbf{ST} * \left({}_{\mathbf{n=1}}\sum^{\mathbf{n=7}} \mathbf{BP_n} * \mathbf{X_n} * \mathbf{C_n}\right)$Above model is applied in the eight cases discussed in this paper. Data collected by conducting direct interviews at various levels of the organizations on each of these seven parameters on a 10 point scale. If the vendor transparency exists, the score will be 10, if not exists it will be 5, the degree of variations are measured in the in-between scale, so do all other parameters. Resultant scores are applied on the above prediction

Table 22.4 Prediction of implementation time frame

		Actual (months)	Prediction (months)	Variation %
1	Case-1	12	11	−9
2	Case-2	15	17	12
3	Case-3	14	16	13
4	Case-4	15	17	24
5	Case-5	Stop	Stop	–
6	Case-6	60	55	9
7	Case-7	36	34	6
8	Case-8	34	40	10

model. The prediction is shown in the Table 22.4. Accuracy of prediction in the range of 76–94 % is shown as the following.

22.6 Conclusion

It is evident from the above analysis that prediction of ERP implementation success is possible through the seven behavior parameters of people involved in the project. All these seven parameters can be measured up front before starting the project. The study provides the business community following advantages:

- Exhibits the readiness of the organization for this change
- Evaluate the team involved in the implementation process
- Pinpoints possible course correction required for the success of the implementation
- Reduce risk
- Save huge implementation cost
- Save the time and effort required for the implementation.

Annexure: A

Case number	Company	Status
1.	(A glass manufacturing company in India) SAP implementation in 6 month	Successful
2.	(A construction group with nine companies in Saudi Arabia). JD Edwards Enterprise one implementation for one company in 6 months)	Successful
3.	(A medical equipment sales and service organization in Saudi Arabia), JD Edwards Enterprise one implementation in 6 months)	Successful
4.	(A construction company in India), JD Edwards Enterprise one implementation in 6 months)	Successful
5.	(Group with more than 50 Higher sec. schools in Dubai), Custom developed ERP implementation, More than 15 months implementation, project stopped	Failure
6.	(An IT services organization in India), Tried JD Edwards implementation for 4 years failed, then started Oracle E-business suite implementation for 1 year	Failure
7.	(A polymer products manufacturing company in India), JD Edwards Enterprise one implementation. Went live in 12 months, implementation team left immediately, Localization module not stabilized, went for re-implementation after 6 months.	Failure
8.	(A needle manufacturing company in India), JD Edwards Enterprise one implementation, Gone live in 15 months, system crashed, re-implementation started after 6 months)	Failure

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Chapter 23
Research on Allocation of Resource in Manufacturing Grid Based on Bi-level Programming

Xiang-bin Zhang and Zhi-xian Wu

Abstract In order to make the manufacturing grid complete the manufacturing tasks and meet the market demand with low-cost and high-quality, the paper presents a resource allocation model based on bi-level programming. In this model intermediary service node and resource service node are taken as the two-layer of the decision interaction, the target of upper level is to minimize the cost of the total grid operation and the target of lower level is to maximize the benefits of every resource node. To achieve the minimal overall operating cost, the two layers pass parameters repeatedly to reach the optimal solution within the range of probabilities. Finally, the paper proves the validity of the model through a computational example. This model provides a new solution to optimize resource allocation of manufacturing grid.

Keywords Bi-level programming · Manufacturing grid · Optimal allocation of resources

23.1 Introduction

Manufacturing Grid (MG) is an advanced manufacturing mode, it is used to respond to economic globalization, information grids and service grids challenge within the limited resources conditions. The target of MG is to share design, manufacturing,

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technology and information resources. Meanwhile, another aim of MG is to have the complementary advantages and optimize the combination of configuration of logistics, information flow, and value stream in the process of work (Shi et al. 2010). In MG, the manufacturing resource has the characteristics of distribution, autonomy, dynamic and heterogeneous, so the intermediary service nodes in MG need to allocate a variety of tasks who request service and a variety of resources who can provide services efficiently at fixed period accord to the types, characteristics, time, price and number of tasks, the types, characteristics, number, time and price of resources. These features of the manufacturing resources and tasks make it highly complex in optimal allocation of resources in MG.

In the previous research of optimal allocation of resources in MG, Liu et al. (2003) proposed the concept of self-organizing manufacturing grid and multi-level, multi-objective integer programming scheduling algorithm based on T (time), Q (quality), C (cost) and S (service) through analyzing the theoretical basis and framework of grid technology in manufacturing applications (Liu et al. 2003). Chen et al. (2006) designed a grid resource management model based on the market mechanism. In the model, the service is seen as a valuable economic commodity, the grid is seen as the services market, and different transaction models are provided. The model can realize efficient and flexible service and resource management and scheduling in Grid (Chen et al. 2006). Zhou et al. (2009) proposed manufacturing resources optimization model based on the approaches to fuzzy comprehensive evaluation, considering major factor on the choice of manufacturing resource nodes synthetically. The model provided Reasonable resource selection and optimal allocation of program to manufacturing resource requests of different users (Zhou et al. 2009). Qu et al. (2010) achieved good results using mobile Agent as carrier of task the user submitted and using genetic algorithm and ant colony algorithm to find and match the grid resources (Qu et al. 2010). Nabrzyski et al. (2003) expounded the grid resource scheduling system must be using a hierarchical structure in the form and proposed grid resource scheduling process can be divided into three stages: resource discovery stage, system choice stage and work performance stage. The study provided a clear architecture for grid resource scheduling (Nabrzyski et al. 2003). In conclusion, these models or strategies did not emphasize the role of intermediary service node in the allocation of resources. Meanwhile, they ignored that the manufacturing resource service node was an independent organization: it would make optimization choice to pursue their own best interests according to the decision in the grid. On the other hand, the decision made by manufacturing resource service nodes would also affect the allocation of resources in the whole grid. The interactive relationship between two layers corresponds to the characteristic of bi-level programming model. Bi-level programming mathematical model was first proposed by Bracken and McGill (1973), now the bi-level programming has been widely used in network design (Ben-ayed et al. 1988), traffic control (Yang and Yagar 1994), Allocation of resources (Cassidy et al. 1971) and so on.

This paper constructs a two-layer model of resource allocation using bi-level programming theory. The model can find the optimal allocation of resources by many decision interactions between intermediary service nodes and resource service nodes. It can make the manufacturing grid complete the manufacturing tasks and meet the market demand with low-cost and high-quality and enhance the core competitiveness of MG.

23.2 Description and Assumptions

In MG, when a manufacturing task arrived, the intermediary service node will decompose and planning it according to its own characteristic and decompose the whole task into several subtasks. Then the node search the Manufacturing Grid Information System (MGIS) in line with the description of resource task required to find the candidate resource service node to complete the task. At last, the model can make the manufacturing grid complete the manufacturing tasks and meet the market demand with low-cost and high-quality by means of transferring parameters many times between intermediary service node and resource service node. Suppose that a local manufacturing grid has resource service nodes (the quantity is m) and a resource intermediary node, within a planning cycle, complete a task need many of the resources u_i, $i = 1, 2, 3, \ldots, n$, the corresponding parameters of the model of bi-level programming are as follows:

p_{i}—the quotation of resource i;
y_{ij}—the quantity of resource i provided by node j;
λ_i—the scale factor of the task decomposition;
k_i—the expense ratio of intermediate nodes;
T_{si}—the start time of resource the task required;
T_{ei}—the end time of resource the task required;
R_{sij}—the start time of resource i provided by node j;
R_{eij}—the end time of resource i provided by node j;
L_i—the work efficiency of tasks needs resources i;
H_{ij}—the efficiency of resource i provided by node j;
$a_{ij},\ b_{ij}$—the supply coefficient of resource i provided by node j;
Y_{ij}—the quantity of resource i node j can provide;
c_{vij}—the variable cost of resource i provided by node j;
c_{Fij}—the fixed cost of resource i provided by node j;

According to the characteristics of resource service node in MG, intermediary service node and bi-level programming theory, the assumptions are as follows: (1) A manufacturing task can have a variety of decomposition of the program, and the amount of resources required are different. (2) A single resource service node provides a kind of resource at least; it can offer many kinds of resources. (3) The resources provided by nodes can be used by the node itself and be sold to other nodes that required; the resource can enter or exit the MG at any time. (4) The resource service nodes are independent and have no cooperation.

23.3 Model Construction

(1) The target of intermediary service node is the lowest operating cost of the local grid:

$$\min TC = \sum_{i=1}^{n} \left[(1 + K_i) p_i \sum_{j=1}^{m} y_{ij} \right] \quad (23.1)$$

There are kinds of resource requirements after the task decomposition:

$$D_\mathrm{i} = \lambda_i T \quad (23.2)$$

The resource requirements all can be satisfied after the task decomposition:

$$\sum\nolimits_{\mathrm{j}=1}^{m} y_{ij} - D_i \geq 0 \quad (23.3)$$

The start time and end time of the resource should meet the following conditions:

$$T_{si} \geq R_{sij} \quad (23.4)$$

$$T_{ei} \leq R_{eij} \quad (23.5)$$

The efficiency of the resource should meet the following conditions:

$$L_i \leq H_{ij} \quad (23.6)$$

The quantity, start time, end time and efficiency of the resources meet the following relationship:

$$D_i = (T_{ei} - T_{si}) L_i \quad (23.7)$$

The constraint of resources offer:

$$0 \leq p_i \leq \overline{p_i} \quad (23.8)$$

The decision variables: p_i—the offer to resource i.

(2) The target of resource service node is the maximization of self-interest

$$\max W = \sum_{i=1}^{n} \left[\left(p_i - c_{Vij}\right) y_{ij} - c_{Fij} + \left(Y_{ij} - y_{ij}\right) \left(v_{ij} - \mathrm{c}_{vij}\right) \right] \quad (23.9)$$

$v_{ij} = a_{ij} \big/ b_{ij}$ stands for the unit revenue when the resource used by itself.

The constraint of the ability to provide resources by resource service nodes:

$$0 \leq y_{ij} \leq Y_{ij} \quad (23.10)$$

The supply curve of resource service node:

$$y_{ij} = -a_{ij} + b_{ij}\, p_i \tag{23.11}$$

The quantity, start time, end time and efficiency of the resource i provided by node j should meet the following relationship:

$$Y_{ij} = \left(R_{eij} - R_{sij}\right) H_{ij} \tag{23.12}$$

The decision variable: y_{ij}.

According to the above discussion, the model can be integrated as follows:

$$BP1 : \min TC = \sum_{i=1}^{n} [(1 + k_i) p_i \sum_{j=1}^{m} y_{ij}]$$

$$s.t. \begin{cases} T_{si} \geq R_{sij}, & i = 1, 2, 3, \ldots, n \\ T_{ei} \leq R_{eij}, & j = 1, 2, 3, \ldots, m \\ L_i \geq H_{ij} \\ D_i = \lambda_i T \\ \sum_{j=1}^{m} y_{ij} - D_i \geq 0 \\ D_i = (T_{ei} - T_{si}) L_i \\ 0 \leq p_i \leq \overline{p_i} \end{cases} \tag{23.13}$$

$$BP2 : \max w = \sum_{i=1}^{n} [(p_i - c_{Vij}) y_{ij} - c_{Fij} + (Y_{ij} - y_{ij})(v_{ij} - c_{Vij})]$$

$$s.t. \begin{cases} 0 \leq y_{ij} \leq Y_{ij} \\ y_{ij} = -a_{ij} + b_{ij} p_i \\ Y_{ij} = (R_{eij} - R_{sij}) H_{ij} \\ \lambda_i \geq 0 \end{cases} \tag{23.14}$$

23.4 Model Algorithm

Solving the bi-level programming problem is very difficult, Jeroslow (1985) pointed out that the Bi-level linear programming is an NP-hard problem. Now, there are some representative algorithms as follows: branch and bound method (Bard and Falk 1982), fuzzy mathematical algorithms (Yuan and Huang 2000) and other intelligent algorithm such as: genetic algorithms (Yin 2000), simulated annealing algorithm (Sahin and Ciric 1998), tabu search algorithm (Gendreau et al. 1996) and particle swarm algorithm. Among this, particle swarm algorithm is not complex crossover and mutation steps, and is easy to operate. The unique memory function of particle swarm algorithm increase the ability of dynamic random search, and showed more excellent in search performance than the genetic algorithm. Now particle swarm algorithm is available as an efficient parallel search algorithm applied to various fields. In this paper, a hybrid particle swarm intelligence optimization algorithm (HPSO) (Kennedy and Eberhart 1995) is used to solve the model.

In HPSO algorithm, a particle stand for one of the top decision-making variables is random search to iterate. It searches for the approximate optimal solution in the feasible region of the top decision-making variables. For the lower-level programming problems of each given particle, we can use simplex method to solve. If the lower-level programming problems of each given particle do not have solutions, the particles will be eliminated as not feasible; meanwhile, the algorithm will regenerate viable particles to replace. The algorithm not only to ensure the solution of each particle and its corresponding lower-level problem in the iterative process has been to meet the constraints of bi-level programming, but also to avoid the use of crossover and mutation steps through some techniques such as step control and infeasible particle phase-out.

23.5 Illustrative Example

Suppose there are 4 resource service nodes and they provide 3 kinds of resources. The manufacturing task is decomposed into 3 resource needs, the information of resources provided by resource service nodes is showed in the Table 23.1. The information of resource needed for the task is as follows in the Table 23.2.

In addition, the total task T = 10, the expense ratio of intermediary service node: $k_1 = k_2 = k_3 = 5\,\%\ 0 \le p_i \le 6$.

According to constraints of work time of resource and efficiency of resource, we determine that the resource 1 is provided by node 1 and 2, the resource 2 is provided by node 1 and 4, the resource 3 is provided by node 3 and 4. Bi-level programming model is as follows:

Table 23.1 The information of resources provided by resource service nodes

Resource node	N1			N2		N3		N4	
Types of resource	S1	S2	S3	S1	S2	S1	S3	S2	S3
Work time	(0, 5)	(1, 6)	(4, 9)	(0, 6)	(2, 6)	(1, 6)	(2, 9)	(2, 8)	(1, 8)
Efficiency	1	1.5	1	1	1	1	1	1.5	1
Quantity	5	7.5	5	6	4	5	7	9	7
Variable cost	0.5	0.4	0.4	0.3	0.6	0.7	0.5	0.5	0.3
Fixed cost	2	0.8	1	1.5	1.2	1	1.5	1.5	0.8
Coefficient (a, b)	2, 2	3, 2	1, 2	1, 2	3, 2	3, 2	2, 2	1, 2	2, 2

Table 23.2 The information of resource needed for the task

Scheme	First scheme			Second scheme		
Types of resource	1	2	3	1	2	3
Decomposition coefficient	0.3	0.3	0.4	0.4	0.3	0.3
Work time	(0, 3)	(2, 4)	(3, 7)	(0, 4)	(2, 4)	(3, 6)
Efficiency	1	1.5	1	1	1.5	1
Quantity	3	3	4	4	3	3

$$\begin{aligned}
\min TC &= (1+k_1)p_1(y_{11}+y_{12}) + (1+k_2)p_2(y_{21}+y_{24}) \\
&\quad + p_3(1+k_3)(y_{33}+y_{34}) \\
\max w_1 &= p_1 y_{11} - y_{11} + p_2 y_{21} - 1.5 y_{21} + 7.95 \\
\max w_2 &= p_1 y_{12} - 0.5 y_{12} - 0.3 \\
\max w_3 &= p_3 y_{33} - 1.5 y_{33} + 5.5 \\
\max w_4 &= p_2 y_{24} - 0.5 y_{24} + p_3 y_{34} - y_{34} + 2.6
\end{aligned}$$

Constraints of the first scheme (Fig. 23.1):

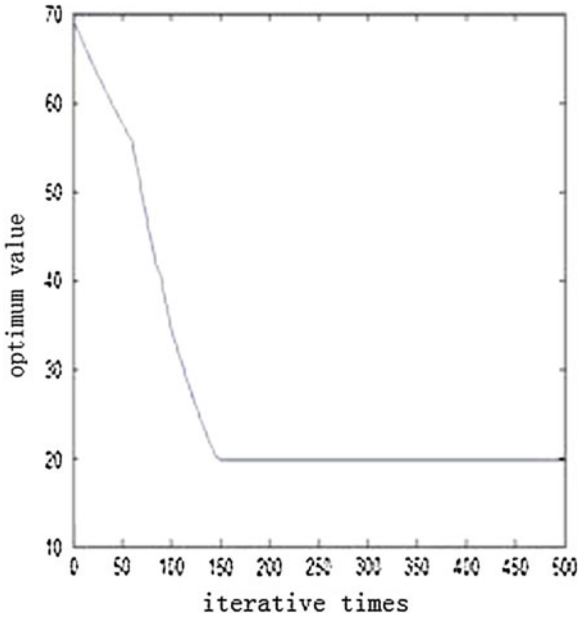

Fig. 23.1 The iterative process of the algorithm in the first scheme

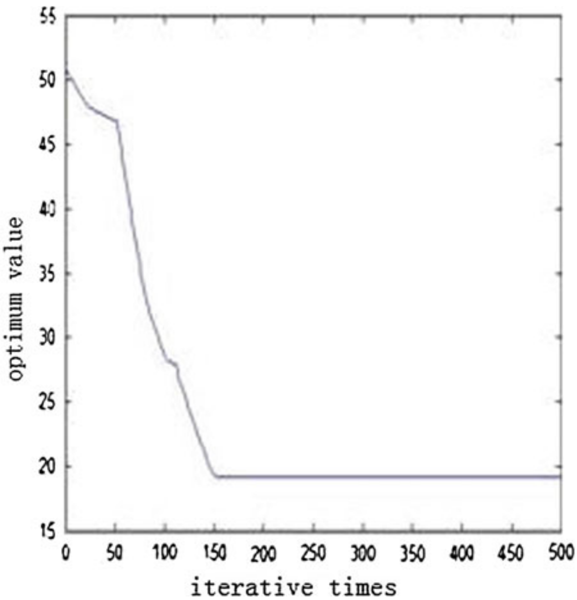

Fig. 23.2 The iterative process of the algorithm in the second scheme

$$s.t.\begin{cases} 0 \le p_i \le 6 \\ 0 \le y_{11} \le 5,\ 0 \le y_{21} \le 7.5 \\ 0 \le y_{12} \le 6,\ 0 \le y_{33} \le 7 \\ 0 \le y_{24} \le 9,\ 0 \le y_{34} \le 7 \\ y_{11} + y_{12} \le 3,\ y_{21} + y_{24} \le 3 \\ y_{33} + y_{34} \le 4 \end{cases}$$

Constraints of the second scheme (Fig. 23.2):

$$s.t.\begin{cases} 0 \le p_i \le 6 \\ 0 \le y_{11} \le 5,\ 0 \le y_{21} \le 7.5 \\ 0 \le y_{12} \le 6,\ 0 \le y_{33} \le 7 \\ 0 \le y_{24} \le 9,\ 0 \le y_{34} \le 7 \\ y_{11} + y_{12} \le 4,\ y_{21} + y_{24} \le 3 \\ y_{33} + y_{34} \le 3 \end{cases}$$

Programming in Matlab7.1 using the hybrid particle swarm algorithm, the optimal solution is as follows:

The first scheme

$$\begin{aligned} &p_1 = 1.50,\ \mathrm{p}_2 = 1.75,\ \mathrm{p}_3 = 2.25 \\ &y_{11} = 1.00,\ y_{12} = 2.00,\ y_{21} = 0.50, \\ &y_{24} = 2.50,\ y_{34} = 2.50,\ y_{33} = 1.50 \\ &w_1 = 8.575,\ w_2 = 1.700,\ w_3 = 6.625,\ w_4 = 8.850 \end{aligned}$$

The total cost of the local grid to complete the task:

$$TC_1 = 19.6875$$

The second scheme

$$\begin{aligned} &p_1 = 1.75,\ p_2 = 1.75,\ p_3 = 2.00 \\ &y_{11} = 1.50,\ y_{12} = 2.50,\ y_{21} = 0.50,\ y_{24} = 2.50, \\ &y_{34} = 2.00,\ y_{33} = 1.00 \\ &w_1 = 9.200,\ w_2 = 2.825,\ w_3 = 6.000,\ w_4 = 7.725 \end{aligned}$$

The total cost of the local grid to complete the task:

$$TC_2 = 19.1625$$

The path of the group extreme value in process of algorithm:

By comparing the calculation results, we know $TC_2 < TC_1$, so it is better to choose the second scheme. The numerical example shows that the bi-level programming model this paper used can solve problem of the optimal allocation of resources in MG effectively, it can make the local grid complete the manufacturing task with the minimum cost.

23.6 Conclusions

To sum up, We can draw the following conclusions through this paper: The paper established a bi-level programming model; the two layers pass repeatedly parameters to reach the optimal solution within the range of probabilities to achieve the minimal overall operating costs. There is no complicated calculation in the hybrid particle swarm algorithm the paper used. The actual program efficiency of HPSO is quite high in the iterating process of resource allocation. In the numerical examples, we analyzed two schemes of resource requirements of task decomposition, and then we chose the better one through comparing the calculation results. In the end, we gained the solution of the minimum operating cost in several schemes. This paper breaks the original resource allocation method and provides a new idea for optimal allocation of resources in MG.

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Chapter 24
Research on Textile Industry Development Strategy and Industrial Distribution in Binhai New Area

Xiao-fei Bai and Liang Liu

Abstract The development of the textile industry of Binhai New Area plays a significant role for regional economic development. In this paper, we analyzed the development status of the textile industry in Binhai New Area, expounded the advantages and disadvantages, identified the opportunities and challenges, and then put forward the development strategy of the textile industry of the Binhai New Area. Subsequently, we proposed to play the cluster effect of the textile industry chain of Binhai New Area as well as build a public service system platform to promote the development of Binhai New Area textile industry. We also studied the distribution of textile industry of Binhai New Area.

Keywords Binhai New Area · Development strategy · Industrial distribution · Textile industry

24.1 Introduction

Facing the trend that the global textile production capacity continues to be surplus, and the opportunities that a worldwide transfer of industries and industrial re-structing is in progress, Chinese textile industry must re-adjust their position in the global textile industry chain (Lei et al. 2005; Huang and Luo 2005; Dong and Zeng

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2006). The textile industrial structure of Binhai New Area is irrational, and the industrial chain structure is not complete. Therefore, in this paper, we analysis the current situation of the textile industry of Binhai New Area, and give some develop strategy to improve the competitiveness of the textile industry. We also study the industrial distribution of textile industry of Binhai New Area.

24.2 Lecture Review

Related researches of Industrial distribution originated in the early "Location Theory", major representatives were Thunen, Weber et al. While some scholars of the former Soviet Union proposed "the territorial production complex theory", which is a product of the planned economy period. The beginning on the industrial distribution study in China was relatively late. Actually, a few geographers and economists have done some surveys on mining and manufacturing in the 1940s, and introduced theories of foreign industrial distribution. In the 1950s, with the country's industrial construction, economic geography workers introduced some literatures about the former Soviet Union industrial distribution and industrial geography (Pilipenko 2005).

In 1990, Porter (1998) proposed that the term industrial clusters could be used to analyze cluster phenomenon in his book "Competitive Advantages of Nations". Until the early 1990s, the cluster theory was introduced to our mainland. Earlier research on Industrial Clusters was done by Wang (2001), a professor of Peking University. She started the follow-up study of enterprise clusters, and published the book "room for innovation: enterprise clusters and regional development", systematically introduced the domestic and foreign industrial clusters in the main schools of thought. Gai (2002) systematically studied the regional innovation networks, and constructed "regional innovation network theory" by applying the economies of scale, scope economies, transaction costs, competitive advantage and innovation theory, which revealed the development of the network of industrial concentration and innovation of new industrial zones.

Recently the related study at home and abroad began to focus on the internal mechanism of industrial clusters to enhance the competitiveness (Huang 2012; Becchetti and Rossi 2000; Cooke et al. 2005). Anthony and Geng (2005) used the strengths, weaknesses, opportunities and threats (SWOT) grouping to classify the preconditions of industrial ecology in Asian Developing Countries. Lu and Yu (2010) described the diamond model to study the interactive development of the industrial cluster and amended after the diamond model for explaining dynamic mechanism of interaction development of industrial clusters and specialized market from the micro-level. Overall, the competitiveness of industrial clusters, especially in Chinese textile, and the core competitiveness of empirical research are in their infancy.

24.3 "Swot" Analysis

24.3.1 Strengths

1. Geographical advantages.
   The Binhai New Area is located in the Eastern Coast of Tianjin, which is adjacent to Beijing and Tianjin. Its occupation of the core position of the Bohai Economic Rim, neighboring Japan and Korean Peninsula just across the sea, facing the Northeast Asia and the rapidly rising Asia–Pacific Economic Rim, and exposure to the global economy has brought the Binhai New Area enormous opportunities of development.
2. Economic policy advantages.
   As a municipality, Tianjin is one of Chinese economically developed areas, especially; its industrial foundation is relatively good. In addition to relying on the macroeconomic of Tianjin, Binhai New Area also has its own outstanding policy advantages. It owns a batch of functional economic zones, including state-level development zones, bonded zones, marine high-tech zones, and export processing zones. And lastly, it has accumulated a wealth of experience in how to utilize the resources and operate the markets both internationally and domestically, fostering a group of export-oriented personnel who master the international advanced technology and the knowledge of modern management.
3. Market advantages.
   Tianjin owns a good industrial foundation, containing a batch of internationally renowned industrial enterprises, such as Boeing, Motorola, Samsung, which are located in Binhai New Area and offer a stable demand of textile, especially the high-performance fiber products. Furthermore, high-tech industrial textile itself has already gained good market potential in Tianjin. Meanwhile, the petrochemical industries of the around provinces such as Hebei, Shanxi, are relatively backward, which implies a greater market penetration for the development of petrochemical downstream industrials in Tianjin.
4. Logistical advantages.
   As an important hub that connects the place home and abroad, Binhai New Area owns a developed Three-dimensional transportation network of sea, land and air. First, The Tianjin Port is among the top 20 of the world deep water ports and is an important sea channel of the Central and Western. Second, the Binhai International Airport is our country's important trunk airport and Northern air cargo center. All of these advantages will sure to greatly contribute to accelerate the circulation of the various industrial products of Binhai New Area, even achieve a nationwide sale. Therefore, all kinds of textiles should focus on the national market as well as global, rather than confined to the local market.

24.3.2 Weaknesses

1. Industrial structure fragmented, with no formation of a complete industrial chain.
   For the moment, Binhai New Area's textiles' structure is irrational, with an incomplete industrial chain. High-performance fiber and industrial textile industries are almost in a blank state. Meanwhile, traditional textile industries which located in intra-city are of low actual competitiveness and low industrial concentration, not able to form industrial agglomeration advantages. Also, even local material supply of textile for clothing and high-performance industries has not yet fully embodied its advantages. Moreover, Tianjin has not yet formed a complete and well-known professional market of the textile industry to promote product sales and form the industrial chain advantages.
2. Market disadvantages.
   Consider all the developed textile industries in our country, they all have a significant feature in common, that is the interaction between industry and market. On the one hand, industry cluster is conducive to the formation of the professional market, which will in turn further promote the development of industrial clusters. Because Tianjin's industrial economics has adjusted the traditional manufacturing industries such as textiles, the textile industry is not dominant in terms of economy, especially there is no docking of the country's textile industrial clusters and professional market. The final sales channel is an unavoidable weakness for the development of textiles of Binhai New Area.

24.3.3 Opportunities

1. Huge development potential of petrochemical industries, which is conducive to joint development with the textile industry
   The petrochemical industry is one of the most basic industrial sectors of the national economy. The national economy can not develop without the support of the petrochemical industry. Sustained and rapid growth of the petrochemical industry, can effectively promote the development of agriculture, machinery, construction, textile, and other related departments, thus contributing to the rapid development of the entire national economy. Domestic petrochemical products will maintain its high growth in the coming 10 years, which is greatly beneficial to the downward extension of the petrochemical industry chain, so as to achieve joint development with the textile industry.
2. Related plans of our country and Tianjin can offer guidance for the development of the textile industry of Tianjin
   The restructuring and revitalization plan of the national textile industry proposed that, eastern coastal areas with developed textile industries should make full use of the advantages of technology, capital, R&D, brands and marketing channels, and track the latest international technologies and products, and focus

on the development of textile industries and products with high technological content, high added value, low resource consumption. "Tianjin economic development Eleventh Five-Year Plan" indicated that, the textile industry should vigorously adjust the product structure to achieve breakthroughs in key products and key technologies, and form a close industrial chain, develop a batch of brand products, construct a textile industry base which sets R&D, manufacturing, marketing, logistics as one, so as to bring an agglomeration effect, thus comprehensively enhancing the level of industry and its synthesized competitiveness. All of these guaranteed the textile industry of Tianjin a bright future.

24.3.4 Threats

1. Environmental constraints.
   In recent years, although the textile and chemical fiber processing technology and textile dyeing process has made significant progress, the contradiction between the development of chemical fiber, dyeing technology and the environmental capacity, aggregated emissions is increasingly prominent. Therefore, when well developing the textile industry, we should increase the intensity of environmental remediation at the same time, including adopting cleaner production processes, minimizing pollution from the source of production. Meanwhile, be sure to implement comprehensive control of "The Three Wastes" in the industrial park to make all contamination indexes up to emission standards, which will accordingly increase some invest costs.
2. Related supporting industries and public services are inadequate.
   The northern economic agents tend to be scattered, while the southern rely on clusters to win; the industrial chain of northern economy is far from obvious, while the southern economy is with a strong supporting capacity. Due to the incompletion of the industrial chain of Tianjin textiles, the comprehensive costs is increased, which is inconvenient for the introduction of larger projects. In addition, there is a shortage of public service platform aiming at solving common industrial technologies and integrating social sources.
   According to the anlysis of the external and internal environment, we made a corresponding strategy for the development of textile industry in the Binhai New Area, as is shown in Fig. 24.1.

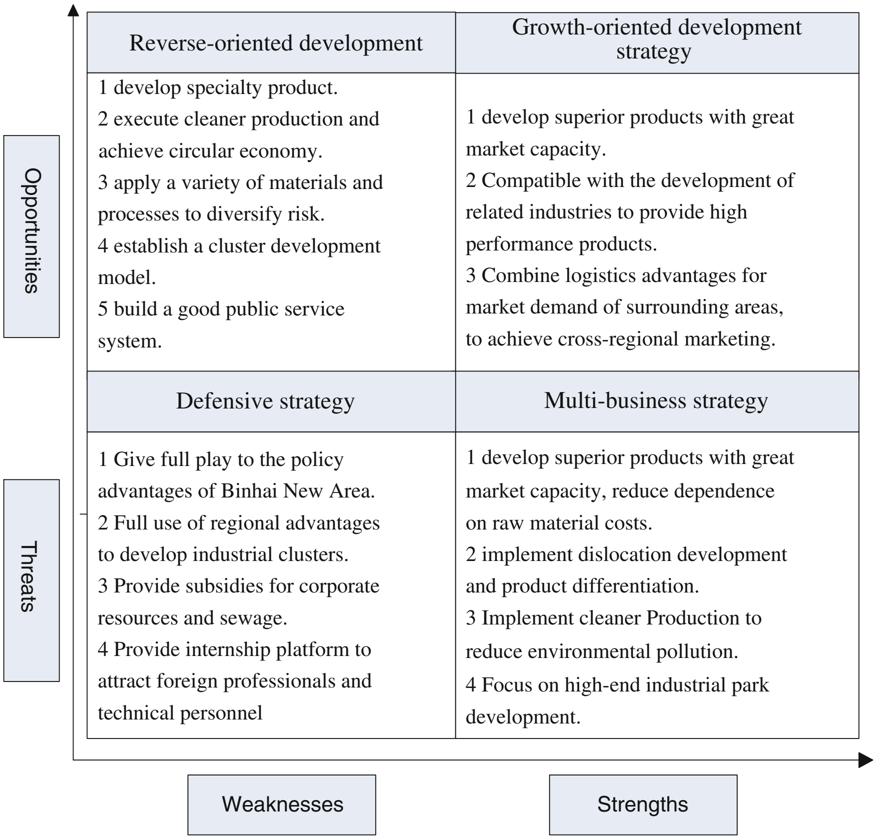

Fig. 24.1 “SWOT” analysis model

24.4 Industry Development Strategy

24.4.1 Play the Cluster Effect of the Industrial Chain

Textile industry cluster refers to a number of interrelated companies in the textile field grow into a textile industry group with a sustainable competitive advantage, including textile companies, specialized suppliers, service providers, manufacturers of related industries and universities, industry associations, relevant government departments and other support agencies (Guo 2012).

The biggest advantage for Binhai New Area to develop textile industry is its industrial chain. A complete industrial chain can be a steady stream to attract enterprises to join this sound ecological environment. At the same time, the optimization of the industrial chain support upstream and downstream industries and the industrial division of labor to refine the various links to the scientific division of labor. Thereby it reduces production costs and operational risks, and ultimately has achieved significant benefits. The textile industry of Binhai New Area needs to rely on the advantages of upstream petrochemical industry, seamless linking the petrochemical industry and textile industry, giving full play to the combined effect of the industrial chain, greatly reducing the costs of organizing textile enterprises and transaction costs, and thereby foster the development of Binhai New Area comparative advantages of the textile industry, attracting superior domestic textile enterprises combinated.

Textile industry cluster networks can be built from two aspects. First of all, it contains textile enterprises' competitive, complementary businesses, upstream petrochemical enterprises as suppliers, as well as the needs of enterprises of textile products. Secondly gather relevant agencies to provide support services for the operation of these enterprises, including government agencies, infrastructure and public service platform. By the construction of the cluster network, it improves the degree of contact of the whole industry chain, and promotes the horizontal and vertical development of the industrial chain. The Relationship of the textile industry cluster network has shown in Fig. 24.2. Lines represent the cluster network relationships. The outer circle contained entities services in the inner business and related activities supported through public service platform.

24.4.2 Construction of Public Service Platform

Textile Industrial Zone in Binhai New Area will be built the important textile industrial base in northern China, chemical products distribution center, petro-chemical downstream industries, processing, trading, logistics center. The goal

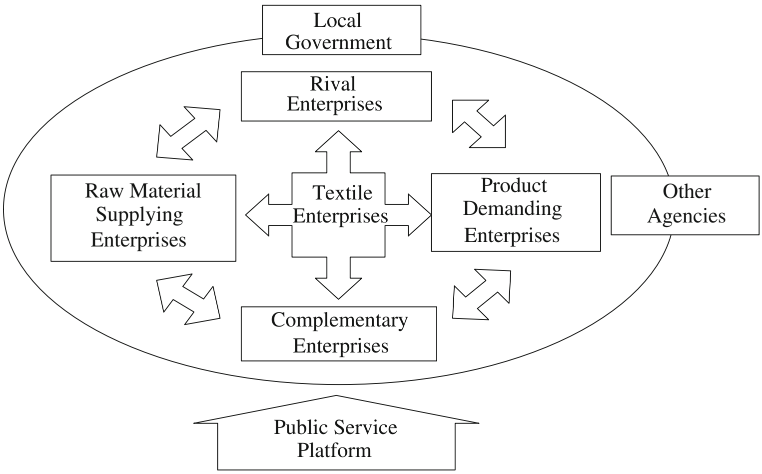

Fig. 24.2 The Relationship of the textile industry cluster network

will requires a fully functional and the service ability of the public service platform for practical serving the majority of enterprises. Therefore it needs to build public service platform, including product development, quality testing, and promotion of social responsibility, e-commerce and logistics and so on.

1. R&D system.
   R & D system adhere to technological innovation, information services and technology into applications for the purpose. Market-oriented and enterprises as the mainstay, and actively take the "research", "science", "industry" innovative path of development. Full-service provides for the majority of SMEs, including the latest textile raw materials, fabric, decorative fabric, craft weaving, environmental protection dyeing technology information and research, style and pattern development and design, consulting and intellectual property protection.
2. Quality inspection system.
   Relying on the China Textile Information Center/National Textile Product Center, it develops textile business standard system based on international and international buyer standards. The same time, the product testing system is one of the core projects of public service platform. Establish an authoritative testing organization in the industry cluster area can be very good for all SMEs enterprises within the cluster. The local government may rely on product testing center to implement effective monitoring the quality of the leading products in the cluster. And improve the regional level of product quality. The sound development of the cluster economy is very favorable.
3. Social responsibility to promote the system.
   The social responsibility to promote the system is the interface between the Office of the Social Responsibility of China Textile Industry Association and business platform, included in the Nanhang textile industrial park public service platform for the pilot. It plays an important role to assist suppliers to achieve supply chain management, to set up the social responsibility performance disclosure mechanism, to regularly publish social responsibility reports or sustainability report, to announce the status of corporate social responsibility, programs and measures, to improve the social responsibility of communication and dialogue mechanisms, to understand and respond to the views of the stakeholders suggested, to take the initiative to accept the supervision of stakeholders and society.
4. E-commerce and modern logistics system.
   E-commerce represents the future of commodity trading model. E-business models can create more and more in-depth business opportunities. E-commerce is using information technology to stimulate industrialization, so we can adopt the concept of e-commerce, and try to adopt e-business models to promote their products, to expand the international market of industrial clusters. The establishment of a modern logistics system can push cluster logistics to a more advanced stage (Yao 2012). Industrial innovation platform can attract logistics companies to join by project bidding.

24.5 Industrial Distribution Research

24.5.1 Location Support

Textile-industrial economic area of Binhai New Area is located in the southeast of the Binhai New Area, 45 km distance from the Tianjin area, 40 km from Tianjin Airport, 20 km from Tianjin Port. The planning area is 200 square kilometers, including a land area of 162 square kilometers, 38 square kilometers of sea area. It is located in the most active in the center of Northeast Asia, whose economic develops fast. It is the eastern starting point of the Eurasian Continental Bridge. The Textile-industrial economic area is not only the sea ports of the Republic of China and Mongolia signed, but also the marine outfall that Kazakhstan and other landlocked countries can make use, with the “three North” the vast space of the radiation (Fig. 24.3) (Sun 2011).

24.5.2 Raw Material Support

Textile-industrial economic area located in the famous Dagang Oilfield, it is rich in oil resources. Tianjin also is a famous petrochemical base. Plenty of petrochemical raw materials will push the textile-industrial economic area being an important production base of synthetic fibers, synthetic resins and other petrochemical downstream products. Thus raw materials will support the development of textile-industrial economic area.

Fig. 24.3 The regional location of textile-industrial economic area

24.5.3 Technical Support

Not long ago, the country's largest fiber interface processing technology industrial base in the Binhai New Area officially started construction. The project is based on the Tianjin Polytechnic University, supporting large ethylene project of Binhai New Area. The project will help promote the textile upgrading of traditional industries. The construction of the project is undoubtedly support the Textile-industrial economic area products into high-end.

Textile-industrial economic area is aimed to undertake downstream petrochemical products, rely on the raw material of synthetic fibers, synthetic resins, synthetic fiber, and vigorously develop the textile industry. In the future, Binhai New Area will form a"Oil head—the Petrochemical body—Textile End" petrochemical industrial chain, a complete system from the "crude oil" to "textile fabrics". Therefore, with the textile industries as a support, a strong petrochemical middle and lower absorption of the digestion of Textile Economic Area came into being.

24.6 Conclusion

Industrial distribution problem is an important issue in regional economic research; while industrial cluster theory plays a significant role for regional economic development. Industrial clusters need to make full use of market mechanisms and organizational mechanisms on the basis of intrinsic and orderly division of labor, through the collaboration and specialization within the region to enhance the competitive advantage of industrial clusters. In this paper, we analysis the problems in the development of the textile industry of Binhai New Area, we proposed that by increasing the degree of industrial clusters to promote the improvement of the industrial chain, and by building a public service platform to improve the operational efficiency of the cluster network. Through the above work, we can promote the development of the textile industry of Binhai New Area.

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Chapter 25
Service Scheduling Optimization in the Next Generation Networked Manufacturing Systems

Lei Zhang, Feng Ding, Ya-dong Fang and Jian-yun Wu

Abstract Cloud Manufacturing and Manufacturing Grid represent top two newest implementations of Networked Manufacturing. This paper embeds Semantic Manufacturing Grid into cloud and then introduces a new concept, namely, Semantic Manufacturing Grid embedded Cloud (SMGeC). Service scheduling optimization as a core issue of SMGeC, is primarily achieved by service composition optimization. So firstly, a DAG based sub-job process model is defined, which predetermines the service process model for service composition optimization. Then, another determinant for service composition is QoS, which is usually carried by SLA. Customized QoS is designed for SMGeC's SLA, along with its hierarchy used for weight designation resorting to FAHP. And then, the five-step procedure and its formalization of service scheduling optimization are discussed. Finally, an abnormal solution proof and time critical path based mathematical model of service composition optimization is proposed. Test shows that the methods and models proposed in this paper are positively feasible and efficient.

Keywords Cloud Manufacturing · Manufacturing Grid · Networked Manufacturing · Service-embedded manufacturing · SOA

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25.1 Introduction

SOA (Service Oriented Architecture) based collaborative manufacturing systems guides the next generation Networked Manufacturing infrastructure. The newest concept emerged for Networked Manufacturing is Cloud Manufacturing (CMfg) (Li et al. 2010), which grows out of cloud computing and provide a new host environment for one of its nearest ancestor—Manufacturing Grid (Fan et al. 2003). It is reasonable to materialize a Cloud Computing environment by embedding Manufacturing Grid into it to construct a kind of Manufacturing Cloud, since the primary capability of cloud computing is to provide mass virtual resource helping to enable Iaas, PaaS, and SaaS. And it is convincing that this kind of Cloud Manufacturing system will be a promising solution of next generation SOA based inter-organizational collaborative manufacturing system, further with an automation enabling technology, namely, Semantic Web. So, we propose a new concept of Networked Manufacturing implementation, namely, Semantic Manufacturing Grid embedded Cloud (SMGeC), meaning a Cloud based Semantic Manufacturing Grid (Zhang et al. 2011) aiming at boosting service-embedded manufacturing and manufacturing service crowdsourcing (Howe 2008), where cloud acts as the fundamental virtual environment hosting the grid.

For SMGeC, core issues involve manufacturing resource virtualization, service based encapsulation, service integration, and service discovery have been studied in our preceding researches (Zhang et al. 2011a, b, 2007). Then the prime issue left is service scheduling. For SOA based Manufacturing Grid or Cloud Manufacturing, researchers have done some illuminative work on service scheduling. Yuan et al. (2005), proposed a dynamical resource scheduling method according the activity requirements and resource QoS capabilities, which can select the 'best match' resource according to scheduling algorithms based on AHP. Hu and Li (2009) studied scheduling of manufacturing grid workflows by heuristic search algorithm based on timed Petri nets. He Yu'an et al. (2009) proposed a manufacturing task planning method, period-cost optimization method and algorithm based on activity period. Lartigau et al. (2012) focused on Manufacturing Cloud environmental data and constraints, and proposed an optimized methodology for the scheduling process. Li et al. (2012) put forward a solution of request dispatching based on stochastic advanced Petri net and queue balancing cutover (QBC) strategy. Fei Tao et al. (2012) discussed using particle swarm optimization (PSO) and scale-free network for service composition in Manufacturing Grid and Cloud.

This paper concentrates on the QoS (Quality of Service) based service scheduling optimization model, including fundamental process/workflow modeling, SLA (Service Level Agreement) negotiation, and QoS based service composition model towards holistic optimization.

25.2 Analysis of Service Scheduling

In SMGeC, job (or task) represents stochastic manufacturing requirement or market opportunity related to physical product or virtual service all over the lifecycle of some kind of product (Zhang et al. 2011). Simple job is a kind of job expected to be accomplished by one service. Others are complex jobs and need to be split up iteratively into simple jobs until each sub-job can find at least on service. It is natural that simple job can be treated as a special case of complex job containing only one simple job.

Service scheduling optimization in SMGeC is essentially service composition optimization. That is, to discover and select a most suitable service for each sub-job in a process model so as to maximize the holistic QoS. So, the mathematical model of service composition optimization is constrained by:

(1) Sub-job process model, which is the outcome of job splitting, and candidate services for each sub-job.
(2) QoS indices and corresponding weights of each index.
(3) Volume of service QoS indices returned from service providers.

25.3 Definition of Sub-Job Process Model

Approaches of automatic or semi-automatic service composition can be concluded into two categories, including intelligent planning and workflow technology. The former has high dynamicity, automation and flexibility, but has rigor prerequisites such as the full, holistic, and rich prior knowledge of the service community. So, workflow may be the best choice for physically distributed, loose coupling, information asymmetric, and information inadequate SOA based inter-organizational manufacturing system.

Among workflow approaches, BPEL4WS, Process Algebra, Petri net, state chart, and Semantic Web based workflow language are popular. Petri net is a very powerful graphical and mathematical modeling language suitable for the description of asynchronous, concurrent, distributed systems. But if employed in service scheduling, it leads to difficulty and hard to control because of complicate control structure such as if–then, iteration, loop, especially for multiple QoS indices aware scheduling. For SOA based inter-organizational system, Petri net is more suitable for long running and stable workflow modeling, so do other approaches such as BPEL4WS, state chart.

DAG (Directed Acyclic Graph) is a very popular graphic process model, which founds the core of many complex workflow models. So we propose a DAG based simplified graphic process model of Petri net and state chart named SJDAG (Sub Job DAG). SJDAG is a semi-automatic service composition approach, since it is supervised job splitting and acts as the template for composition. It extends AOE (Activity On Edge) network, a kind of DAG, and defined as follows.

- Edge, represents a sub-job, expressed by the set of sub-job description, candidate services with their SLA's list, selected service with its SLA. Data structure of an edge SJ:

$$SJ = < SJD, CSL, SS > , \tag{25.1}$$

$$CSL = \{ < CS_1, SLA_1 > , < CS_2, SLA_2 > , \ldots, < CS_n, SLA_n > \}, \tag{25.2}$$

$$SS = < S, SLA > . \tag{25.3}$$

wherein: JD is the semantic description of a sub-job. CSL is the list of candidate services discovered by semantic matchmaking based on JD, along with a SLA slot for each service which will be materialized after a round of negotiation between service consumer and providers. The structure of JD and the method of matchmaking is specified in our preceding work (Zhang et al. 2007). SLA is conventionally a QoS container. SS is a slot of selected optimal service along with its ultimate SLA, and will be materialized after service composition optimization and contract validation.

- Vertex represents event of sub-job transition.
- Atomic logic structure. SJDAG defines four atomic logic structures as shown in Table 25.1. A job diagram can be arbitrary combined by these four types of structures. But cycle is not permitted, since SJDAG stands upon DAG. Adjacency matrix or list can be used to store SJDAG to facilitate service composition optimization algorithm.

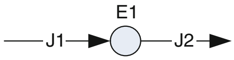
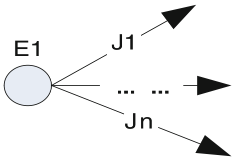
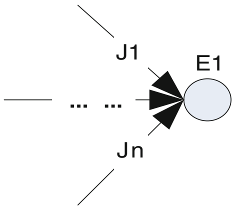
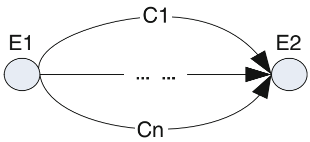
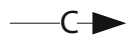
25.4 QoS Design for SLA

SLA (Mitchell and Mckee 2005) is a key guarantee in Web Service community. In SMGeC, it serves as a warrant for manufacturing resource reservation and QoS obligation. WS-Agreement is a draft of SLA standard, and literatures (Wu and Jin 2005) have already studied its semantic model. Components of SLA are universal and applicable to all cases except QoS, which is the core component of SLA. So we extend the QoS of semantic WS-Agreement to specify the SLA model of SMGeC. Four categories QoS indices are primarily considered including (market or manufacturing response) time factor, cost factor (of service consumer need to pay), quality factor (of service or product), and guarantee ability (of contract). Then a concluded QoS model is defined as Formula (25.4).

$$V_{QoS} = < V_T, V_Q, V_P, V_{VS}, V_R, V_K, V_E, V_{SR} > \tag{25.4}$$

wherein: V_{QoS} is the vector of QoS indices. V_T, V_Q, V_P, V_{VS}, V_R, V_K, V_E, V_{SR} mean manufacturing time duration, quality, price, value-added service (i.e. extra quality

Table 25.1 Four atomic logic structures in SJDAG

Label	Legend	Definition
Sequence		Event E1 happens just after sub-job J1 completes, and triggers sub-job J2 starting
Parallel split		Event E1 triggers all the outwards connected sub-jobs from J1 to Jn starts simultaneously. n ≥ 2
Parallel join		Event E1 happens just after all the inwards connected sub-jobs from J1 to Jn end up. n ≥ 2
Parallel split + join		"  " represents one sub-job or a combination of the preceding 3 types of structures. Event E1 triggers all the outwards connected sub-jobs or combinations from C1 to Cn starts simultaneously. Event E2 happens just after all the inwards connected sub-jobs or combinations from C1 to Cn end up. n ≥ 2

assurance time), reputation, knowledge capability, reliability, and success rate respectively. 3 indices including V_T, V_P, V_{VS} need to be provided by service provider. Four indices including V_Q, V_R, V_E, V_{SR} are provided by a SMGeC third party supervision center. V_K is the degree of service match, which comes from service discovery (Zhang et al. 2011a, b, 2007) with the value between 0 and 1.

The indices are organized into a hierarchy as shown in Fig. 25.1. The weights of eight indices at the third layer relative to the total goal (first layer) can be calculated resorting to FAHP (Fuzzy AHP).

25.5 Formalization of Service Scheduling

Using SJDAG as the template, SMGeC service scheduling optimization reduces to SJDAG and QoS constrained service composition, aiming at highest holistic QoS. Then as shown in Fig. 25.2, service scheduling optimization in SMGeC can be carried out according the following five steps.

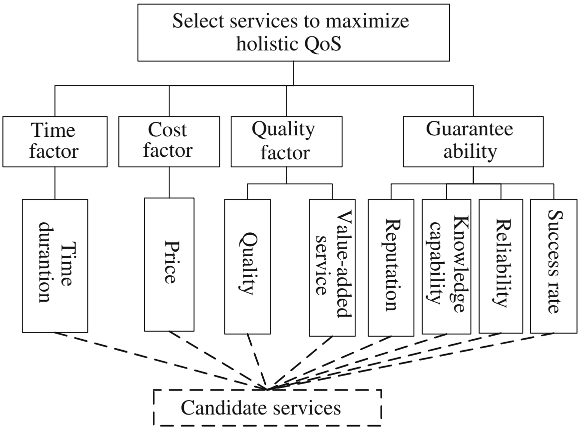


Fig. 25.1 Hierarchy of QoS in SMGeC

(1) Job analysis. Designate job-specific weights for QoS indices resorting to FAHP (Fuzzy AHP). Split up a job into a sub-job process model according to SJDAG, and generate a semantic description (Zhang et al. 2011a, b, 2007) for each edge (representing a sub-job) with the help of some kind of tool such as OWL-S Editor.
(2) Service discovery. Find a list of alternative services for each sub-job which satisfy the requirement of the sub-job to a relative high degree, e.g. 0.8, through a semantic matchmaking process on register center such as semantic UDDI (Zhang et al. 2011a, b, 2007).

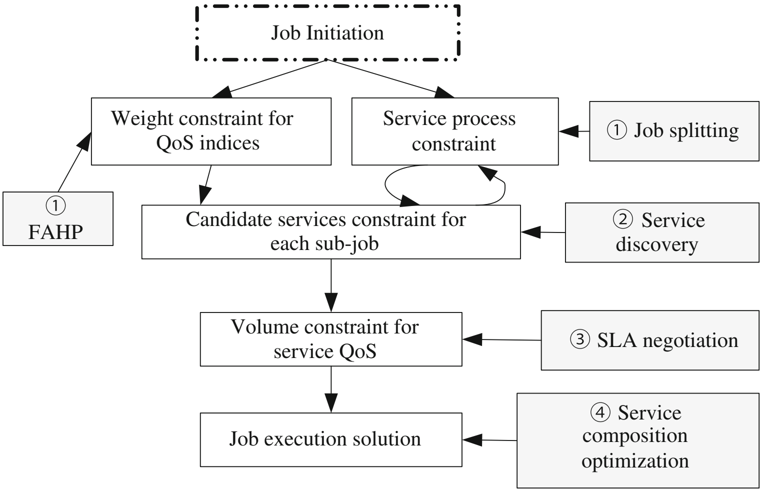


Fig. 25.2 Service scheduling optimization procedure in SMGeC

(3) SLA negotiation. Initiates the interaction between the workflow management service and alternative services in a Tendering & Bidding manner, so as to get the volumes of each service's QoS indices.
(4) Establish multi-objective optimization mathematical model of service composition by determining the optimization objective and constraints.
(5) Solve the model, get the optimal solution.

Job splitting and service discovery are performed iteratively, since job is recursively split from large granularity to small until each sub-job can find at least one service to accomplish it.

Service scheduling optimization can be formalized as follows. When job splitting and service discovery are finished, SJDAG model turns into Formulae (25.5–25.8).

$$SJDAG = \langle SJS, \leq \rangle, \tag{25.5}$$

$$\begin{aligned} SJS &= \{SJ_1, SJ_2, \ldots, SJ_m\} \\ &= \{\langle SJD_1, CSL_1, SS_1 \rangle, \langle SJD_2, CSL_2, SS_2 \rangle, \ldots, \langle SJD_m, CSL_m, SS_m \rangle\} \end{aligned} \tag{25.6}$$

$$CSL_i = \{\langle CS_1, \varnothing \rangle, \langle CS_2, \varnothing \rangle, \ldots, \langle CS_{ni}, \varnothing \rangle\}(1 \leq i \leq m), \tag{25.7}$$

$$SS_i = \varnothing, (1 \leq i \leq m). \tag{25.8}$$

wherein: $\leq$ in $SJDAG$ means partial order, and SJS means sub-job set. $SJDAG = \langle SJS, \leq \rangle$ means a partial order of sub-jobs. SJD, CSL, CS, SS means sub-job description, candidate service list, candidate service, and selected service respectively.

When SLA negotiation is finished, SJDAG model turn will into Formulae (25.9–25.12).

$$SJDAG = \langle SJS, \leq \rangle, \tag{25.9}$$

$$\begin{aligned} SJS &= \{SJ_1, SJ_2, \ldots, SJ_m\} \\ &= \{\langle SJD_1, CSL_1, SS_1 \rangle, \langle SJD_2, CSL_2, SS_2 \rangle, \ldots, \langle SJD_m, CSL_m, SS_m \rangle\}, \end{aligned} \tag{25.10}$$

$$CSL_i = \{\langle CS_1, SLA_1 \rangle, \langle CS_2, SLA_2 \rangle, \ldots, \langle CS_{ni}, SLA_{ni} \rangle\}, (1 \leq i \leq m), \tag{25.11}$$

$$SS_i = \varnothing, (1 \leq i \leq m). \tag{25.12}$$

When composition optimization is finished, SJDAG model turns into Formulae (25.13–25.16).

$$SJDAG = \langle SJS, \leq \rangle, \tag{25.13}$$

$$SJS = \{SJ_1, SJ_2, \ldots, SJ_m\} \\ = \{<SJD_1, CSL_1, SS_1>, <SJD_2, CSL_2, SS_2>, \ldots, <SJD_m, CSL_m, SS_m>\}, \tag{25.14}$$

$$CSL_i = \{<CS_1, SLA_1>, <CS_2, SLA_2>, \ldots, <CS_{ni}, SLA_{ni}>\}, (1 \le i \le m), \tag{25.15}$$

$$SS_i = <S_i, SLA_i>, (1 \le i \le m, S_i \in \{CS_1, CS_2, \ldots, CS_{ni}\}, SLA_i \in \{SLA_1, SLA_2, \ldots, SLA_{ni}\}) \tag{25.16}$$

25.6 Mathematic Model for Service Composition

Service composition will review sets of services by evaluating their QoS's. Quantified QoS indices cannot be immediately compared because of different measurement metrics. So, all the indices of each candidate service are normalized to [0, 1] by max–min scaling method before using them. For convenience, the elements in QoS vector $V_{QoS} = <V_T, V_Q, V_P, V_{VS}, V_R, V_K, V_E, V_{SR}>$ are marked as $V_0, V_1, \ldots, V_7$ in turn. Supposing that the SJDAG of a job J contains m sub-jobs with orders $0, 1, \ldots, m-1$, and the No. i sub-job has n_i candidate services, the No. k QoS index of service S_{ij} is normalized as Formula (25.17).

$$Q_{ijk} = \begin{cases} \frac{V_{ijk} - \min(V_{ik})}{\max(V_{ik}) - \min(V_{ik})}, & \max(V_{ik}) \ne \min(V_{ik}) \\ 1, & \max(V_{ik}) = \min(V_{ik}) \end{cases} \tag{25.17}$$

wherein: $i(0 \le i \le m-1)$ is the No. i sub-job of J. $j(0 \le j \le n_i - 1)$ is the No. j candidate service of the No. i sub-job. $0 \le k \le 7$ is the No. k QoS index. Q_{ijk} is the result of normalization.

From the view of service consumer, QoS indices are divided into two categories according to different role for service selection. They are profit-indices including V_Q, V_{VS}, V_R, V_K, V_E, V_{SR} (i.e. $\{V_1, V_3, V_4, V_5, V_6, V_7\}$), and loss-indices including V_T, V_P (i.e. $\{V_0, V_2\}$). Higher profit-indices benefit the consumer, while the loss-indices are reverse. So the PPR (performance/cost ratio) of S_{ij} is defined, and to be calculated by Formula (25.18).

$$B_{ij} = \frac{w_1 \frac{V_{ij1} - \min(V_{i1})}{\max(V_{i1}) - \min(V_{i1})} + \sum_{k=3}^{7} \left(w_k \frac{V_{ijk} - \min(V_{ik})}{\max(V_{ik}) - \min(V_{ik})} \right)}{w_0 \frac{V_{ij0} - \min(V_{i0})}{\max(V_{i0}) - \min(V_{i0})} + w_2 \frac{V_{ij2} - \min(V_{i2})}{\max(V_{i2}) - \min(V_{i2})}} \tag{25.18}$$

wherein, w means weight.

Abnormal solution may be generated while searching optimal solution using Mathematical Programming or modern optimization algorithm. However, it is impossible to determine the most suitable threshold before composition. We use a constraint to explicitly control the threshold to decrease step by step, so as to ensure the quality of optimal solution.

In SMGeC, the objective of service composition optimization can be specified as maximizing the holistic PPR of the service composition while ensuring that total time and price do not exceed budget. Conditions:

(1) The SJDAG of job J contains m sub-jobs, and each sub-job SJ_i get n_i candidate service resorting to semantic service discovery, $0 \leq i \leq m-1$.
(2) Each QoS index volume of each service $Q_{ijk}(0 \leq i \leq m-1,\ 0 \leq j \leq n_i - 1, 0 \leq k \leq 7)$ has been got.
(3) Weight of each QoS index $w_k(0 \leq k \leq 7)$ has been figured out.
(4) For job J, the initial threshold vector $QITH = (QITH_k)(k \in \{1,4,5,6,7\})$ and least limit vector $QBTH = (QBTH_k)(k \in \{1,4,5,6,7\})$ of $V_Q, V_R, V_K, V_E, V_{SR}$, along with most decreasing steps (i.e. steps from initial threshold to least limit threshold) QIS are given.
(5) For job J, time budget L_T and price budget L_P, i.e. time and price limit, are given.

Provided these conditions, the objective of composition optimization is to search for a solution $(x_0, x_1, \ldots, x_{m-1})$ in solution space, whose corresponding composition $S = \left(S_{0x_0}, S_{1x_1}, \ldots, S_{(m-1)x_{m-1}}\right)$ (S_{ix_i} means the No. i sub-job selects the No. x_i service from candidate service list) satisfying constrains including QoS thresholds, time budget, and price budget, and can maximize the objective function. The SMGeC service composition optimization mathematical model is defined as Formula (25.19).

$$\max u = \sum_{i=0}^{m-1} B_{ix_i}$$
$$s.t.\begin{cases} \forall(0 \leq i \leq m-1), 0 \leq x_i \leq n_i \\ \forall k \in \{1,4,5,6,7\}, V_{ix_ik} \geq QITH_k \\ \qquad - d \times \dfrac{QITH_k - QBTH_k}{QIS}, (0 \leq d \leq QIS) \\ CPL^* \leq L_T \\ \displaystyle\sum_{i=0}^{m-1} V_{ix_i2} \leq L_P \end{cases} \tag{25.19}$$

wherein: d is the current decreasing step. CPL^* is the time length of the critical path of SJDAG if adopting the current service composition as the solution. CPL^* is calculated by extracting the time duration value from currently selected services' SLA's.

To select m service from $n_1, n_2, \ldots, n_m$ candidate service for m sub-jobs, is a NP-hard problem of combinatorial optimization. For a non-convex optimization problem, many modern optimization algorithms can be employed, such as

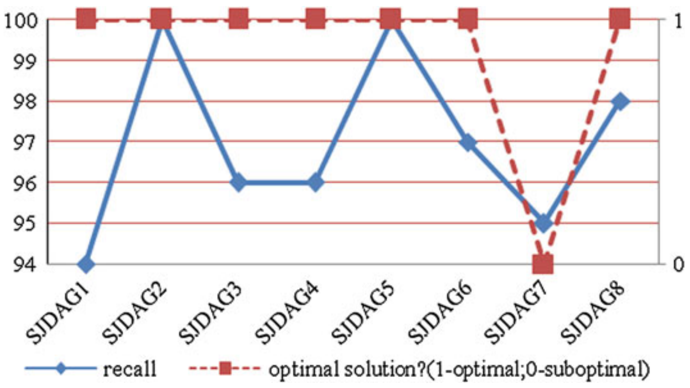


Fig. 25.3 Test results of service scheduling optimization in SMGeC

Simulated Annealing (SA), Neural Network (NN), Genetic Algorithm (GA), Tabu Search/Taboo Search (TS) and Ant Colony Optimization (ACO).

25.7 Evaluation

A prototype of SMGeC is implemented by upgrading our preceding prototype of SMG (Zhang et al. 2011a, b, 2007). For the purpose of feasibility and efficiency evaluation, a service scheduler is developed as a couple of services itself. In this scheduler, SA is adopted as the solving algorithm for the service optimization mathematical model with amelioration towards manufacturing time critical path and automatic decreasing of QoS threshold. Degree threshold of semantic matchmaking used in service discovery is set to 0.8. Eight SJDAG's with 8 sub-jobs each are tested against 120 services with average candidate services is 5. Results in Fig. 25.3 show that the methods have acceptable performance, where recall means the service discovery or semantic matchmaking capability and "optimal solution?" means if or not can get the optimal at the first run of composition optimization.

25.8 Conclusion

SMGeC is an amalgamation of Cloud Manufacturing and Manufacturing Grid, the top two kind of prominent Networked Manufacturing implementations. It embeds grid into cloud environment so as to provide a feasible crowdsourcing manufacturing infrastructure, and is a promising next generation Networked Manufacturing system. This paper focuses on the service scheduling issue of SMGeC, which is essentially a service composition optimization problem. It defined a sub-job process model named SJDAG, designed QoS indices for SLA, and defined the abnormal solution proof and time critical path based mathematical model for service composition optimization. Test shows that the methods and models this paper proposed are positively feasible and efficient.

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Chapter 26
Study on Comprehensive Evaluation of Iron and Steel Enterprises Production System's Basic Capacities

Tao Li and Hong-wei Liu

Abstract On the purpose of improving the basic capacities of iron and steel enterprises production system, this paper establishes an evaluation indexes system which contains production planning and process, equipment management, quality management, team construction, cost control, flexibility, site management and environment protection. A comprehensive model for evaluating the basic capacities of iron and steel enterprises production system is proposed, where the result is evaluated by fuzzy comprehensive evaluation. A large iron and steel enterprise of China is selected to apply this evaluation model, and the result reveals many advantages in this model that the evaluation is objective, operational and effective. By the discussion of case study, several suggestions are proposed to improve the basic capacities of this enterprise's production system.

Keywords Production system · Capacities evaluation · Fuzzy analytic hierarchy process · Fuzzy comprehensive evaluation

26.1 Introduction

With the development of production management, enterprises production system's basic capacities evaluation gets more and more attention, which is a significant constitution of production management. The traditional production management is focus on the inner of production system, and it pays more attention to system operating. The problem they mostly concern is how to improve the production efficiency. As a result, the evaluation of production system is center on efficiency; what is more, the evaluation indicators are almost about the output rates.

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Li et al. (2005) analyzed the problems of efficiency management existed in manufacturing production system, and established an efficiency evaluation system for manufacturing production system, which contained planning, improving, site and logistics, man-hour and financing. Contraposing the problem that it is hard to quantitatively analysis low efficiency, Zhang et al. (2008) proposed different evaluation indicators according to various mode of production, such as mass production, unit production, multispecies production, which are focus on production's total output value, labor productivity, overall equipment effectiveness and so on. Ye et al. (2001) established an evaluation indicators system based on operating system productivity. Vokurka and Fliedner (1995) took the method of combining economic indicators and non-economic indicators to appraise the performance of enterprise production and operation. Adanondo (1997) made an appraisal for the production system from the point of multilevel inventory level. Wan and Da (2003) and Liu and Li (1999) designed the flexibility indicators of production system. From the above we know that different research scholars have different views in choosing indicators of production system evaluation, but most of them think highly of production efficiency, which is incomplete.

Combination of quantitative evaluation and qualitative evaluation is the most common method in evaluation. Su and Wei (1999) chose fuzzy comprehensive evaluation method to evaluate the production system. Xia et al. (2012) proposed a DEA efficiency evaluation model for mixed-continuous production system. Wang et al. (2003) designed a common method to measure the flexibility of production system based on three-dimensional vector theory. Pang and Du (2005) used analytic hierarchy process in evaluating the flexibility of production system. Jain et al. (2004) gave an evaluation of the entry of production system by applying evolutionary fuzzy-based approach. In addition, Costa and Oliveira (2012) adopted multi-criteria decision analysis method to appraise the capacities of a complex system.

From above mentioned, different appraisal methodologies would have different focuses and could result to different appraisal results. What is more, they are emphasis on different aspects of production system. For example, data envelopment analysis emphasis on the efficiency of production system, while fuzzy comprehensive evaluation method lays more stress on comprehensiveness and integrality. It is critical that we choose the most suitable evaluation method according to our purpose and the indicators. From all the methods mentioned above, fuzzy comprehensive evaluation has obvious superiority in quantitative appraisal and comprehensive evaluation, because it accomplishes comprehensive evaluation by the combination of qualitative evaluation and quantitative compute which would get rid of subjectivity. In this paper, we adopt fuzzy comprehensive evaluation method to evaluate the basic capacities of iron and steel enterprises production system, whose indicators' weights are determined by fuzzy analytic hierarchy process.

26.2 Basic Capacities Evaluation Model

Several premises have to be observed before we establish the evaluation index system for iron and steel enterprises production system's basic capacities. First, we should conform to the common rules and methods. Second, we must refer to other researchers' achievements and the characters of iron and steel industry. Only in this way could we form an evaluation index system scientifically and reasonably.

In this paper we design an evaluation indexes system, which contains production planning and process, equipment management, quality management, team construction, cost control, flexibility, site management and environment protection, through combining the general characters of iron and steel industry and the fundamental management features. The evaluation indicators are divided into three levels by analytic hierarchy process on the basis of its constitution and connotation. As shown in Table 26.1. There are both quantitative indicators and qualitative indicators in this index system, whose economic sense, manifestation, dimension etc. have great differences. So it is necessary that the indexes get nondimensionalization. We adopt fuzzy quantitative statistics and standardization to qualitative indicators and quantitative indicators respectively.

26.3 Empirical Analysis

26.3.1 Production System's Basic Capacities Evaluation of C Iron and Steel Co., Ltd

C Iron and steel Co., Ltd is one of Chinese large state-owned iron and steel enterprises, whose iron annual output is more than 800,000,000 tons. What's more, its operation administration pattern is very typical in China state-owned iron and steel enterprises. An investigation about the company's basic capacities of production system was conducted to discover the defects exist in its production system; also it could help the company to confirm the steps which could enhance the basic capacities of production system. And then a comprehensive appraisal was made by the evaluation model we introduced above. There were 2842 copies of questionnaires have been distributed in this investigation, and recovered 2270 copies. The recovery rate was 79.9 %, which was acceptable. The evaluation matrixes were established based on the results of the questionnaire. The weights of every indicator were determined by fuzzy analytic hierarchy process, as shown in Table 26.2. The specific calculation process was omitted as the limited length of this article. The second grade indicators and third grade indicators' weights were determined by the same method. The weights of indexes system and the evaluation matrixes of third grade indicators are shown in Table 26.3. From the table we can conclude that the fuzzy evaluation matrixes of first grade indicators are:

Table 26.1 Basic capacities evaluation index system for iron and steel enterprises production system

First grade indicators	Second grade indicators	Third grade indicators	First grade indicators	Second grade indicators	Third grade indicators
Production planning and process	Due date	Planning completing rate	Cost control	Raw material cost control	Purchasing
		Contracts completion rate			Consumption
		Process on time delivery rate		Staff salaries	Labor quota
					Work time utilization
		Operating rate			
	Capacity to finish production plan	Production targets achieving rate		Process cost	Activity-based costing
					Quality cost
		Yields difference rate			
	Production stability	Process stability		Logistics cost	Internal logistics cost
		Process connection		Inventory	Product inventory
		Fuel supplying			Work in process inventory
		Equipment movable rate			
		Takt time			Raw material inventory
	Balance of production	Process synchronization	Flexibility	Product flexibility	Yields flexibility
		Variety switching			Variety flexibility
					Extension flexibility
Equipment management	Management institution	Soundness degree		Production flexibility	Staff flexibility
		Level of enforcement			Equipment flexibility
	Efficiency	Overall equipment effectiveness			Planning flexibility
	Equipment maintenance	Period of inspection	Site management	5 s management	Participation degree of staff
	Equipment fault	Tons of steel repairs			
		Mean time to faults			Implementation effect
					Visual management level
		Outage rate		Standard work	Quantization degree
		Total outrage time			Ownership level
		First qualified rate			Execution level

(continued)

Table 26.1 (continue)

First grade indicators	Second grade indicators	Third grade indicators	First grade indicators	Second grade indicators	Third grade indicators
Quality management	Stability of quality	Quality consistency			
		Procedures qualified rate	Environment protection	Input (tons of steel)	Scrap steel coefficient
	Quality system building	Quality targets achieving rate			Mineral consumption
		Process approach			Comprehensive energy consumption
		Customer satisfaction			New water consumption
	Improving and innovation	Management reviews implementing		Output (tons of steel)	Offscum emission
					Dust emission
		Corrective and preventive action			Waste gas emission
					Wastewater emission
		Education and train			
Team construction	Team culture building	Cost awareness		Circular economy	Water circulation utilization rate
		Quality awareness			Gas recovery utilization rate
		Staff quality			Industrial solid wastes utilization rate
	Safety building	Safety production			Industrial effluents recycle rate
		Staff satisfaction			Industrial solid wastes emission decreased rate
	Staff morale	Staff enthusiasm			Industrial effluents emission decreased rate

Table 26.2 First grade indicators' weights

Iron and steel enterprises production system's basic capacities	Team construction	Equipment management	Cost control	Quality management	Site management	Production planning and process	Flexibility	Environment protection	Weight
Team construction	0.50	0.37	0.45	0.42	0.52	0.30	0.63	0.44	0.11
Equipment management	0.63	0.50	0.58	0.55	0.65	0.43	0.76	0.57	0.14
Cost control	0.55	0.42	0.50	0.47	0.57	0.35	0.68	0.49	0.13
Quality management	0.58	0.45	0.53	0.50	0.60	0.38	0.71	0.52	0.13
Site management	0.48	0.35	0.43	0.40	0.50	0.28	0.61	0.42	0.11
Production planning and process	0.70	0.57	0.65	0.62	0.72	0.50	0.83	0.64	0.16
Flexibility	0.37	0.24	0.32	0.29	0.39	0.17	0.50	0.31	0.09
Environment protection	0.56	0.43	0.51	0.48	0.58	0.36	0.69	0.50	0.13

Table 26.3 Indexes' weights and fuzzy evaluation matrixes

First grade indicators	Weight	Second grade indicators	Weight	Third grade indicators	Weight	Fuzzy evaluation matrix					Score
						Excellent	Good	Ordinary	Poor	Bad	
Production planning and process	0.16	Due date	0.26	Planning completing rate	0.39	0.12	0.50	0.20	0.10	0.08	6.96
				Contracts completion rate	0.33	0.38	0.30	0.06	0.17	0.09	7.42
				Process on time delivery rate	0.28	0.45	0.35	0.17	0.02	0.01	8.42
			0.25	Operating rate	0.25	0.18	0.23	0.15	0.19	0.25	5.80
				Production targets achieving rate	0.44	0.20	0.34	0.11	0.12	0.23	6.32
				Yields difference rate	0.31	0.23	0.12	0.25	0.15	0.25	5.86
			0.29	Process stability	0.23	0.11	0.46	0.29	0.10	0.04	7.00
				Process connection	0.25	0.18	0.58	0.13	0.06	0.05	7.56
				Fuel supplying	0.22	0.20	0.26	0.19	0.10	0.25	6.12
				Equipment movable rate	0.30	0.30	0.10	0.18	0.33	0.09	6.38
		Capacity to finish production plan	0.20	Takt time	0.39	0.26	0.21	0.16	0.18	0.19	6.34
		Production stability		Process synchronization	0.30	0.19	0.33	0.12	0.14	0.22	6.26
		Balance of production		Variety switching	0.31	0.21	0.23	0.06	0.40	0.10	6.10
Equipment management	0.14	Management institution	0.14	Soundness degree	0.44	0.28	0.37	0.13	0.16	0.06	7.30
		Efficiency		Level of enforcement	0.56	0.50	0.37	0.05	0.06	0.02	8.54
		Equipment maintenance	0.30	Overall equipment effectiveness	1.00	0.32	0.54	0.07	0.03	0.04	8.14
		Equipment fault	0.28	Period of inspection	0.46	0.22	0.61	0.14	0.02	0.01	8.02
		Stability of quality		Tons of steel repairs	0.54	0.08	0.20	0.29	0.35	0.08	5.70
			0.28	Mean time to faults	0.39	0.24	0.54	0.05	0.03	0.14	7.42
				Outage rate	0.33	0.31	0.47	0.12	0.05	0.05	7.88
				Total outrage time	0.28	0.19	0.35	0.28	0.13	0.05	7.00
Quality management	0.13	Quality system building	0.44	First qualified rate	0.42	0.24	0.38	0.29	0.04	0.05	7.44
		Improving and innovation		Quality consistency	0.33	0.27	0.16	0.26	0.16	0.15	6.48
		Team culture building		Procedures qualified rate	0.25	0.13	0.28	0.27	0.10	0.22	6.00
			0.20	Quality targets achieving rate	0.26	0.45	0.16	0.22	0.06	0.11	7.56
				Process approach	0.32	0.30	0.33	0.28	0.01	0.08	7.52
				Customer satisfaction	0.42	0.22	0.17	0.20	0.25	0.16	6.08
			0.36	Management reviews implementing	0.43	0.14	0.23	0.11	0.35	0.17	5.64
				Corrective and preventive action	0.57	0.22	0.22	0.24	0.13	0.19	6.30

(continued)

Table 26.3 (continued)

First grade indicators	Weight	Second grade indicators	Weight	Third grade indicators	Weight	Fuzzy evaluation matrix					Score
						Excellent	Good	Ordinary	Poor	Bad	
Team construction	0.11	Safety building	0.33	Education and train	0.30	0.14	0.23	0.35	0.17	0.11	6.24
		Staff morale		Cost awareness	0.16	0.19	0.37	0.09	0.20	0.15	6.50
				Quality awareness	0.22	0.25	0.24	0.28	0.06	0.17	6.68
				Staff quality	0.32	0.12	0.25	0.18	0.05	0.40	5.28
			0.33	Safety production	1.00	0.20	0.56	0.21	0.02	0.01	7.84
			0.34	Staff satisfaction	0.57	0.19	0.25	0.31	0.11	0.14	6.48
				Staff enthusiasm	0.43	0.12	0.42	0.29	0.08	0.09	6.80
Cost control	0.13	Raw material cost control	0.35	Purchasing	0.54	0.33	0.35	0.21	0.08	0.03	7.74
		Staff salaries		Consumption	0.46	0.21	0.36	0.35	0.07	0.01	7.38
		Process cost	0.15	Labor quota	0.56	0.44	0.21	0.13	0.13	0.09	7.56
		Logistics cost		Work time utilization	0.44	0.20	0.34	0.35	0.07	0.04	7.18
		Stock	0.15	Activity-based costing	0.49	0.12	0.50	0.20	0.10	0.08	6.96
				Quality cost	0.51	0.19	0.28	0.21	0.10	0.22	6.24
			0.20	Internal logistics cost	1.00	0.25	0.20	0.13	0.23	0.19	6.18
			0.15	Product inventory	0.38	0.18	0.34	0.13	0.29	0.06	6.58
				Work in process inventory	0.30	0.13	0.45	0.10	0.17	0.15	6.48
				Raw material inventory	0.32	0.18	0.35	0.19	0.16	0.12	6.62
Flexibility	0.09	Product flexibility	0.59	Yields flexibility	0.39	0.35	0.13	0.15	0.20	0.17	6.58
		Production flexibility		Variety flexibility	0.33	0.35	0.29	0.12	0.07	0.17	7.16
				Extension flexibility	0.28	0.44	0.21	0.13	0.13	0.09	7.56
			0.41	Staff flexibility	0.37	0.26	0.30	0.15	0.12	0.17	6.72
				Equipment flexibility	0.33	0.12	0.32	0.14	0.17	0.25	5.78
				Planning flexibility	0.30	0.30	0.25	0.14	0.14	0.17	6.74

(continued)

Table 26.3 (continued)

First grade indicators	Weight	Second grade indicators	Weight	Third grade indicators	Weight	Fuzzy evaluation matrix					Score
						Excellent	Good	Ordinary	Poor	Bad	
Site management	0.11	5 s management	0.59	Participation degree of staff	0.37	0.21	0.54	0.23	0.01	0.01	7.86
		Standard work		Implementation effect	0.42	0.64	0.20	0.09	0.05	0.02	8.78
		Input (tons of steel)		Visual management level	0.21	0.25	0.20	0.20	0.17	0.18	6.34
			0.41	Quantization degree	0.35	0.44	0.21	0.13	0.13	0.09	7.56
				Ownership level	0.21	0.23	0.18	0.33	0.08	0.18	6.40
				Execution level	0.44	0.07	0.20	0.16	0.29	0.28	4.98
Environment protection	0.13		0.28	Steel scrap coefficient	0.15	0.26	0.30	0.15	0.12	0.17	6.72
				Mineral consumption	0.35	0.23	0.27	0.20	0.17	0.13	6.60
				Comprehensive energy consumption	0.23	0.37	0.32	0.12	0.07	0.12	7.50
				New water consumption	0.27	0.07	0.23	0.40	0.18	0.12	5.90
		Output (tons of steel)	0.43	Offscum emission	0.21	0.49	0.17	0.24	0.07	0.03	8.04
		Circular economy		Dust emission	0.23	0.40	0.11	0.29	0.17	0.03	7.36
				Waste gas emission	0.21	0.29	0.45	0.19	0.03	0.04	7.84
				Wastewater emission	0.35	0.42	0.17	0.16	0.14	0.11	7.30
			0.29	Water circulation utilization rate	0.13	0.31	0.53	0.10	0.04	0.02	8.14
				Gas recovery utilization rate	0.25	0.35	0.20	0.29	0.11	0.05	7.38
				Industrial solid wastes utilization rate	0.21	0.22	0.25	0.20	0.17	0.16	6.40
				Industrial effluents recycle rate	0.21	0.13	0.45	0.10	0.17	0.15	6.48
				Industrial solid wastes emission decreased rate	0.10	0.35	0.20	0.08	0.29	0.08	6.90
				Industrial effluents emission decreased rate	0.10	0.26	0.33	0.20	0.11	0.10	7.08

$$E_1 = G_1^T \times M_1 = (0.1751\,0.3808\,0.2505\,0.0766\,0.1170)$$
$$E_2 = G_2^T \times M_2 = (0.2599\,0.4444\,0.1362\,0.1036\,0.0558)$$
$$E_3 = G_3^T \times M_3 = (0.2435\,0.3203\,0.2044\,0.1389\,0.0929)$$
$$E_4 = G_4^T \times M_4 = (0.3539\,0.2940\,0.1679\,0.0963\,0.0880)$$
$$E_5 = G_5^T \times M_5 = (0.2235\,0.2488\,0.2333\,0.1491\,0.1453)$$
$$E_6 = G_6^T \times M_6 = (0.2259\,0.3297\,0.1649\,0.1423\,0.1372)$$
$$E_7 = G_7^T \times M_7 = (0.2975\,0.2484\,0.1387\,0.1412\,0.1742)$$
$$E_8 = G_8^T \times M_8 = (0.3119\,0.2620\,0.2066\,0.1285\,0.0910)$$

The final evaluation result is: $W = G^T \times M = G^T \times (E_1; E_2; E_3; E_4; E_5; E_6; E_7; E_8) = (0.2619\,0.3117\,0.1865\,0.1240\,0.1159)$.

We make such conversion to quantize the result as followed. Assuming that the evaluation vector is $V = \{\text{excellent good, general, poor, bad}\} = \{10, 8, 6, 4, 2\}$, in that way the company basic capacities of production system scores are: production planning and process, $V_1 = E_1 \times V^T = 6.6760$ equipment management $V_2 = 7.5432$; quality management, $V_3 = 6.5268$; team construction, $V_4 = 6.8407$; cost control, $V_5 = 6.9693$; flexibility, $V_6 = 6.7875$; site management, $V_7 = 7.2113$; environment protection, $V_8 = 7.1503$.

According to the weights and scores of first grade indicators, we can figure out the company's holistic score: $B = W \times V^T = (0.2619\,0.3117\,0.1865\,0.1240\,0.1159) \times (1\,8\,6\,4\,2)^T = 6.9594$.

26.3.2 Evaluation Result Analysis

In order to evaluate the company's basic capacities of production system, we set such rules.

(1) If the holistic score $B \in [9, 10]$, it reveals the company's basic capacities of production system are excellent, and its production system does have the ability to adapt the daily production targets and development requirements. Therefore, it should keep and solidify its basic capacities.

(2) If the holistic score $B \in [7, 9)$, it reveals the company's basic capacities of production system are dissatisfactory, and its production system could not meet the needs of the company's normal production targets. What's more, it would have a negative effect on enterprise development. Therefore, the company should improve its basic capacities of production system especially its weaknesses in production system.

(3) If the holistic score $B \in [2, 7)$, it reveals the company's basic capacities of production system are very weak, and it could not cope with the normal needs for production. Only if the company takes some targeted actions to improve its fundamental management immediately could it improve its basic capacities of production system.

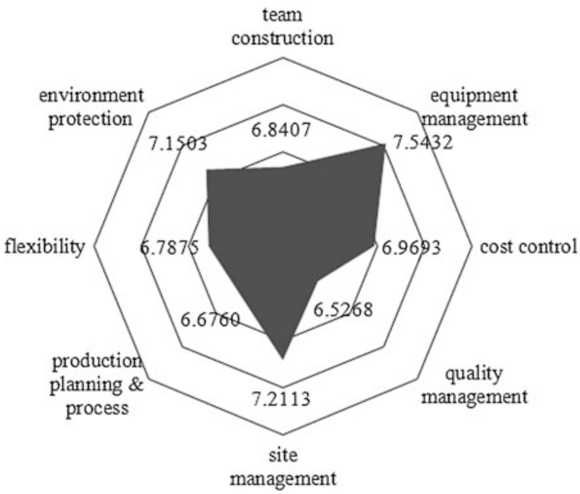

Fig. 26.1 Production system's basic capacities evaluation of C Iron and steel Co., Ltd

From above mentioned we can conclude that our research should focus on the enterprises whose score is below 9. The iron and steel company scores 6.9594, which demonstrate that its basic capacities of production are very weak. From Fig. 26.1 we can visually know that the lowest score in first grade indicators is quality management, which scores 6.5268. What is more, the procedures qualified rate, quality consistency, customer satisfaction and management reviews implementing's score below 6.5. All of these demonstrate that there are serious quality problems in C's products. The procedures qualified rate on the low side would not only direct to quality loss and procedure waste, but also could bring down the first qualified rate which would delay the delivery deadline and influence the customer satisfaction. All of these would have a negative influence on the enterprise competitive power. The problems exist in quality management reflect that the company is lack of production process control, which make a reasonable explanation for why production planning and process got a much low score. Obviously, vulnerable quality management would inevitably lead to cost rising. And cost control scores 6.9693, which confirms that this suppose is rational. We suggest that this company should take great efforts to improve its quality management contraposing the weaknesses discovered in the investigation, such as strengthening process quality control, adopting preventive quality control and continual improvement.

26.4 Conclusion

Aiming at helping the iron and steel enterprises solve the problems of production system operation ability and improving the basic capacities of production system, in this paper, we establish an evaluation model for the basic capacities of production system, which contains a localized evaluation index system, and then choose a

Chinese large state-owned iron and steel enterprise to apply this evaluation model. The results demonstrate that the evaluation model is objective, operational and effective. In addition, the evaluation model provides a scientific foundation and an implementation approach to help the iron and steel enterprise carry out internal appraisal and production system amelioration.

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Chapter 27
A Research into a Method of Enlarging the Cutting Range by Five-Axis Linkage

Xing-guo Liu, An-chuan Liu, Wei-yun Meng, Dong-ye Liu, Qing-ying Zhao and Guang-teng Zhang

Abstract This paper presents a method of enlarging the cutting range by multiple coordinate axes, in which the NC machine tool processes roller gear indexing cams. The relationship between parameters is derived and applied to the programming software. The actual application shows that this method can not only be used to expand the original machine tool processing range, but also be used to adjust the parameters. The stiffness and the processing efficiency of the machine tool are greatly improved by this method.

Keywords Center distance · Five-axis linkage · NC programming · Roller gear indexing cam

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27.1 Introduction

The roller gear indexing cam mechanism is also known as Ferguson drive for indexing machine. It is composed of a roller gear cam and a driven rotary table with rollers, which are equant along the diameter. See Fig. 27.1. There is a ridge in the cam, like a worm, but the spiral angle is variable, not constant. All the roller axes are on the same plane, and in the center of the driven rotary table, each roller axis being in a radial arrangement. The indexing mechanism of the cam does not need any additional positioning device, but has the advantages of simple structure, reliable operation, high indexing precision, small impact vibration, and stable movement, particularly suitable for high-speed intermittent indexing mechanism etc. (Wang 1989).

27.2 Roller Gear Indexing Cam

Owing to the undeployable characteristics of the roller gear indexing cam in space, the processing can only be carried on by two rotary coordinates, and cannot be converted to rectangular coordinates. The processing of the roller gear indexing cam, whether by means of a special NC machine tool or by a general multi-axis NC machine tool, the two rotating shafts should not only meet the meshing transmission requirements, but should also ensure that the center distance is invariant. For a machine tool, the parameter range of the center distance of a

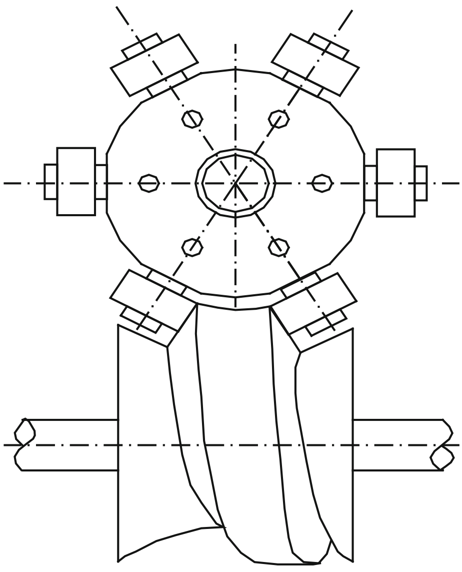


Fig. 27.1 Roller gear indexing cam mechanism

machinable cam is generally limited. When it is beyond the parameter adjustable range, the machine tool will be unable to work.

The special NC machine tool, which is used to process roller gear indexing cam, has two rotating shafts and its center distance is adjustable, which is used to meet the cutting requirements of a cam with different center distances. This kind of special NC machine tool has the advantages of simple structure, good rigidity, low cost, but the processing range is limited, and can only be used for generating cutting. Subject to the limit of the movement structure of the machine and tool limit, the center distance of a general five-axis NC machine is ensured by a mathematical algorithm in the cut of the roller gear indexing cam. In addition to the required A–B rotary motion, two rectilinear coordinates X–Z are needed as the position compensation, in order to ensure that the tool axis is always going through the theory rotary center and coincident with the oscillating center. Thus the processing range is almost unrestricted. But the calculation of programming is complicated, and the equipment cost is high. The XH756 special five-axis NC machine tool has the advantages of the above mentioned two kinds of machine tools, so great improvements have been made in terms of function and performance. Now with this kind of machine tool as an example, let us discuss the processing method of the roller gear indexing cam with big center distances (Liu 2001, 2002, 2003).

27.3 The Coordinate and Structure of the Special Five-Axis NC Machine Tool

The relationship between the coordinate and the structure of the XH756 special five-axis NC machine tool is shown in Fig. 27.2. This kind of machine tool is of horizontal structure, where in the straight shaft are X, Y and Z axes, and their strokes are 850, 700 and 700 mm respectively. The B Shaft is of rotating structure, located above the worktable which is composed of X axis and Y axis, using double lead worm gear drive, high precision grating encoder, the straight diameter, and high strength rolling bearing, the range of motion being about 65°. The A axis is located above the B axis turntable, using high-precision NC rotary dividing head, the center high being 250 mm, and its motion range is 0–360°. W axis, which is used to adjust the center distance of A axis and B axis, and a digital display device are arranged between A axis and B axis, adjustable range being 40–280 mm. Since the machine structure and the tool design are suitable for the work piece center and B axis center to go through the spindle axis, the feed of Z axis is used only to control the cam groove depth, thus the programming and the operation is relatively simple. Disadvantage of this structure is that when the cam center distance is larger and the overhanging of spindle tool holder longer, the spindle stiffness will decrease (Liu 2002; Liao 1992, 2006).

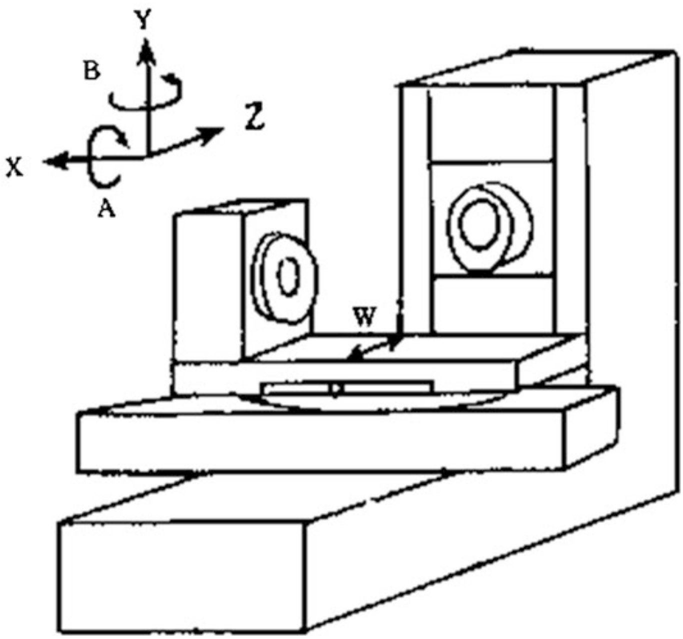


Fig. 27.2 NC machine tool coordinate system diagram

The horizontal structure has simpler machine structure, better rigidity and larger moving range, especially simpler coordinate transformation in blade machining than vertical structure. These features are good for reducing the design and manufacturing costs, improving processing efficiency and accuracy, changing cutters quickly.

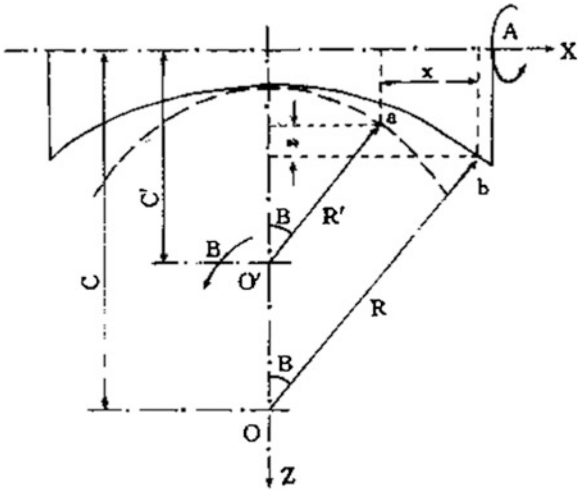
27.4 Coordinate Transformation and NC Programming

27.4.1 Coordinate Transformation

As shown in Fig. 27.3, the research is based on the swing tool processing method. In the graph, O′ is the actual tool swinging center, and O is the driven disc theory swing center. R′ is the actual processing radius of cutters, and R is the theory gyration radius. When the cutter is placed over the B angle, the corresponding processing location is the b point, but the actual tool position is the point. Comparing a with b, we know that the distances of X and Z direction are x and z. When the cutter compensates according to the values of X and Z, we can use a small distance machine to cut the roller gear indexing cam with a large center distance.

From the geometric relationships in Fig. 27.3, we can deduce that:

Fig. 27.3 Coordinate transformation diagram



$$
\begin{aligned}
X &= (R\text{--}R')\sin B = (C\text{--}C')\sin B \\
Z &= R'\cos B - [R\cos B - (C\text{--}C')] \\
&= (C\text{--}C') - (C\text{--}C')\cos B \\
&= (C\text{--}C')(1 - \cos B)
\end{aligned}
$$

It can be seen from the above compensation value is only related with the center distance parameters C of the roller gear indexing cam,the machine tool center distance C′ and the angle B, but irrelevant with the cam rotation angle A (Liu 1991; Tawakoli 2013).

In practical application, C and C′ as the known quantities, the cutter angle B is determined by the movement rate of B = f (A), also as the known quantity in processing. Therefore, the four-axis linkage control of two rotational coordinates A and B and two rectilinear coordinates X and Z will make possible theoretically the processing of the roller gear indexing cam with any center distances. In other words, the roller gear indexing cam with a longer center distance can be processed by the machine tool with a shorter center distance, and vice versa (Machine Design Manual Editorial Group 2013).

27.4.2 Programming in NC Machining

According to the coordinate transformation, X and Z, after the mathematical processing, and as a special module, are added in the roller gear indexing cam automatic programming software, which is developed by the author, and has the cut setting algorithm, the eccentric algorithm, the algorithm of correcting feed speed, cam surface modification and error control of calculation. The cam automatic programming system can realize automatically the coordinate conversion and generate NC program.

27.5 Practical Processing

Now take, for example, the roller gear indexing cam used in the glass machinery. The parameters are as follows:

Model: TH350
Form: type I, L
Center distance: 350 mm
Sub degree: 8
Dynamic ratio: 135°/225°
Roller diameter: 90 mm
The depth of the groove: 48 mm
The radius of the arc: 197 mm
Cam width: 250 mm

The center distance of the roller gear indexing cam for XH756 five coordinate CNC machining is 350 mm, greater than the largest machine adjustable in the range of 40–280 mm, so you can't use it in generating cutting.

When the machine center distance is greater than 220 mm, the length from tool to the spindle end is greater than 350 mm, the spindle elongation will be greater than 520 mm, the machine tool spindle stiffness will be worse, the processing vibration is too large, and the processing precision is poor (Meldas 520M Series Instruction Manual 1998).

According to the spindle stiffness, without generating motion interference, the machine tool center distance is adjusted to 200 mm, then $C = 350$ mm, $C = 200$ mm, based on $x = (R–R)\,\sin B = (C–C)\,\sin B$; $Z = R, \cos B - [R\cos B - (C–C')] = (C–C)\,(1 - \cos B)$, can be used to calculate the X and Z coordinate values of arbitrary A angle and B angle.

The roller gear indexing cam is produced by XH756 for five axis NC machine successfully, after the practical application of users; various parameters are up to or exceed the design index. At the same time, it is the longest center distance of a glucosidal cam.

The actual cutting results show that this method expands the processing range of the original machine tool, so that the center distance is increased from 40 to 280 mm to almost unlimited quantities. It can also be used to adjust processing machine parameters, so that the machine spindle rigidity, the machining precision and efficiency are greatly improved (Meldas 520M Series Programming Manual 1998).

27.6 Conclusion

The use of XH756 for five coordinate NC machining of the roller gear indexing cam will not only make possible the cutting processing, but also the multi-coordinate linkage control to adjust the machining range of the NC machine tool.

The NC machining program is programmed according to the relationships between coordinates. If the above mentioned machine tool is used elastically, its function and its machining efficiency will be brought into full play and the high quality roller gear indexing cam will be manufactured.

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Chapter 28
System Design for Solar Ground Source Heat Pump in Aquaculture

Dan Liu

Abstract To ensure the requirement for water temperature of aquaculture in cold winter, and for the purpose of energy saving and protection of the environment, providing temperature system has been designed. Heat pipe type vacuum tube solar collector to heat taken primarily, solar collector insufficient ground source heat pump added, the water temperature in workshop of breeding fish has been raised. Through two winter tests, the system runs stably, the effect was good at the purpose of the design, saving 70 % of the running costs.

Keywords Aquaculture · Ground source heat pump (GSHP) · Solar energy · System design

28.1 Introduction

At present, the technology of solar energy and ground source heat pump has been developed. Utilization of solar energy and ground source heat pump in cold water domain widens ceaselessly, both environmental protection and energy saving and can save much operating cost. The solar energy and ground source heat pump used in aquaculture, has not caused enough attention at our county (Wang et al. 2009).

With the development of our national economy, people's living standard is improving gradually, the demand for aquatic products showed an upward trend year after year (Zhao and Yang 2009), and aquaculture environmental factors such as large, in China northeast and northwest winter cold areas, some rare tropical aquatic species, even in the room, if not aquaculture water extraction temperature, also cannot achieve growth requirements or slow growth (He 2009). So every year

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in winter, in order to maintain the normal growth of tropical aquatic species, only by the combustion of conventional energy (mainly coal) way to breeding water extraction temperature in cold region, causing great waste of human and material resources, and coal combustion will release of flue gas to pollute the environment (Lv et al. 2009), In order to solve this problem, at the same time, in the winter of cold area, this research to find both an economical and energy saving and environmental protection of the aquiculture way (Mahmoud and Hamdani 2006).

In order to test solar ground source heat pump system in a practical application in aquaculture (Diplas 2007), Harbin sunshine energy combination of limited company of engineering of the second pump plant in Harbin city at 2009 September in Harbin aquatic product research institute indoor pisciculture workshop built test and demonstration project.

28.2 Engineering

28.2.1 Solar Heat Collector

As the project is the main source of the solar collector with heat pipe vacuum tube heat collection system, taking into account the northern winter special cold factors, choice of anti-freezing fluid as heat pipe of the circulating medium of (Wang Chongjie et al. 2007), solve the solar heat collection system antifreeze, collector area a total of about 40 m^2.

28.2.2 Ground Source Heat Pump System

Ground source heat pump unit from Harbin City, the second water pump factory design and processing, the actual power input power 3.5 KW, nominal output power 60 KW. The ground source heat pump system of the circulation mode is a closed cycle, set the circulating liquid by using ethylene glycol, heat circulation pipe diameter Φ20, good thermal conductivity and certain strength PERT tube (Otsuka 2005). Heat pipe layout in the workshop next to every day to drain off water at the bottom of the pond, total 600 m, adopt parallel arrangement, four groups of parallel operation (Yao et al. 2009) (Figs. 28.1 and 28.2).

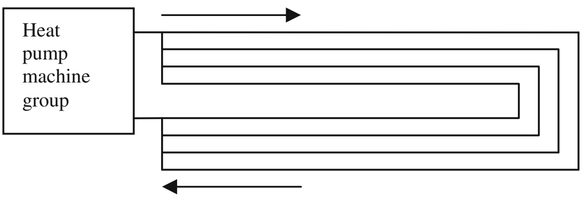
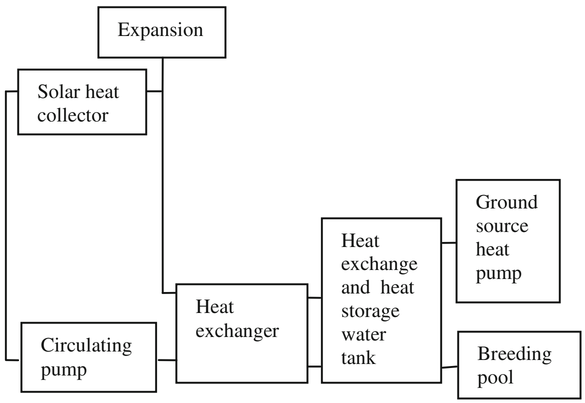


Fig. 28.1 The ground source heat pump heating circulating pipe arrangement

Fig. 28.2 Diagram of system



28.2.3 System Design

The system consists of the Linyi University and Harbin Sunshine Energy Engineering Company Limited and Harbin second water pump factory designed, the system used solar energy and ground source heat pump combined operation mode on the water in the reservoir to raise temperature, solar heat is insufficient to start the ground-source heat pump system to be added (Huang and Chyng 2001), for reservoir in 20t water heating rate of 14 °C.

28.2.4 Control System

This project adopts the automatic control system and the automatic alarm system, the use of professional module collects each control point temperature output signal to the equipment (pump, solenoid valve, pump host etc.), and use the module transmits the signal to the control center, control system for starting and stopping at any time, can also be switched to manual control (Lu 2008). When the system fails, it can be collected by the error information, automatic alarm. The control system is stable in operation, good effect, achieve the expected design objective.

28.3 Energy calculation

Promotion of 20t water of 14 °C calories:

$$Q = CM\,\Delta t \tag{28.1}$$

Q—absorption heat;
C—specific heat, specific heat capacity of water is 4.2 × 103 J/(kg × °C);
M—quality;
T—increased or decreased temperature.

$$Q = 4.2 \times 103 \times 20 \times 103 \times 14 = 1176\ \text{MJ}$$

As in the use of electric heating to warm up,

$$\text{Required power} = 1176 \times 106/3.6 \times 106 = 327\ \text{kW} \cdot \text{h} \tag{28.2}$$

For the solar energy heat collector (Yang and Zhou 2009),

$$Q_u = AG(\tau\alpha)_e - AU_L\left(T_p - T_a\right) \tag{28.3}$$

Q_u—collector within a specified time period the output of useful energy, W;
A—collector area, m^2;
G—solar irradiance, W/m^2;
$(\tau\alpha)_e$—Transparent cover plate transmission and the heat absorbing body absorption rate of product;
U_L—collector overall heat loss coefficient, $W/\left(M^2 \cdot K\right)$;
T_P—the heat absorbing body temperature, °C;
T_a—environment temperature, °C.

According to the manufacturers of solar energy parameters provided by the system used by the solar collector in winter in Harbin fine weather daily calories for 1404 MJ, solar heat collector for heating water conversion rate of 85 %.

20t water capacity of 1404 × 85 % = 1193 MJ > 1176 MJ.

In the vast majority of winter, weather, separate operation of solar collector can satisfy 20t water temperature rising requirement. In the winter snow weather and illumination is insufficient, need to use ground source heat pump to supplement. Heat pump adopt the intermittent operation mode, in the solar energy does not work, only the start of ground-source heat pump units, 5–6 h to reach the temperature required (Cervantes and Torres-Reyes 2002).

28.4 Runing Effect and Cost Analysis

According to 2009 and 2010 winter operation of the system at the time of testing situation, the actual operation results are slightly better than the design, in good weather, even if the cold weather, solar part can also meet to temperature requirements. In the solar energy to weather, heat pumps unit running time than the design of nearly 1 h hour. Analysis of the reasons, in part because the actual solar energy solar energy conversion efficiency than expected when the design efficiency will be higher (Dong et al. 2003). And a pump is in part because fish culture workshop discharge water temperature at about 15 °C, and the water after mixing, the water is used in the design of the temperature must be high (Rodriguez et al. 2009).

Installation of solar ground source heat pump system, with the previous 0.3t/h boiler installation and operating costs compared to a table.

In summary, we believe that the solar energy and ground source heat pump combined with the application in the aquaculture industry, is feasible, all-weather operation, can save operation cost nearly 80 %.

28.5 Summary

The engineering test is successful, the solar energy and ground source heat pump is applied to the joint, as well as the development of the aquaculture industry has very important significance (Table 28.1):

(1) for the future of solar and ground source heat pump system in the aquaculture industry in the application and promotion to provide a successful engineering example.
(2) for solar energy and ground source heat pump combined application and promotion of accumulated experience, gained a lot of valuable data; for solar energy and ground source heat pump application in many fields to build a bridge.
(3) in the actual project in the realization of the solar energy and ground source heat pump combined, and the realization of the system of automatic control and automatic alarm, so the system is more economic and reasonable.
(4) the project investment 153,000 yuan, annual savings in operating costs 81,000 yuan, less than two years to recover the full cost of equipment.

Table 28.1 Solar ground source heat pump unit and 0.3t/h boiler costs (unit: yuan)

	Solar ground source heat pump	3t/h boiler
Equipment and installation cost	Solar energy: 97000	380000
	Ground source heat pump: 56000	
	total: 153000	
He cost of the 20t water heating/month	Solar electricity and water cost: 150	Water, coal, electricity: 2000
	Ground source heat pump: 189	The wages of the stokers: $2200 \times 3 = 6600$
	The wages of the workers: 1500	
	Total: 1849	Total: 8600

Note 1. The operation cost, ground-source heat pump running 10 days per month, running 6 h a day, price: 0.9 yuan/kw, total cost is $3.5 \times 6 \times 10 \times 0.9 = 189$ yuan
2. Solar ground source heat pump system for fully automatic operation, just a worker

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Chapter 29
The Heuristic Balance Design in LCD Display Assembly Line

Yun-rui Wang

Abstract LCD display assembly line includes preceding, middle and posterior segment of three parts, a total of 46 stations, each station there is a clear imbalance, leading to the line cannot play the maximum benefit. First use of the method of work study, testing and research the operation on the middle assembly line, find the bottleneck, the operation time of the bottleneck is compressed by repeated testing and analysis and the beat of the whole assembly line is reduced; and then apply improved heuristic balance method, the operating elements of the station to re-distribute, assembly line workstations decline the number 2, the beat is reduced from 10.5 to 9.98 s, the balance of efficiency from 81.34 to 88.15 %, to achieve the goal of 350 units, the state of assembly line is the best.

Keywords Balance · Beat · Heuristic method · Work study

29.1 Overview

LCD display assembly line composed in 46 stations when in the production of a machine. The assembly operations go through three parts of the preceding, middle and posterior segment. According to the observations of the production operations at the scene, the preceding and posterior segment has reached ideal state, but the middle rely mainly on the experience to solve the balance problem, the middle should be constrained by hardware in test station and affect the station operation

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time. The operation of the assembly line do not consider the actual operation time of the middle now, if the bottleneck time is in the middle, it would lead to the assembly line cannot reach a better state, sometimes has to stop running (Cai et al. 2011).

29.2 Balanced Design of Assembly Lines

29.2.1 Work Study of Assembly Line in Middle

The middle of the assembly line consists of 12 stations, the 12th station is product confirmation, so work study is used in the other stations. Direct time study is the most widely used method in the work (Hou 2008; Guo et al. 2006), and continuous timing measurement recorded at the scene, a stopwatch is walking continuously in the whole process, observer record the time at the end of every operation, after the end of all observation, followed by the subtraction method, find time for operation time of every workstation, a complete procedure is defined as one cycle. The operation time of each station should be added to flow time of 1 s since collector plate turnover is used in assembly line (Gao and Sun 2007). In order to ensure the accuracy of time, each station measured when the number is taken as 10 times, the average 10 is the station operation time, as shown in Table 29.1

It is obvious, operation time of power testing station and high-voltage test station is higher to 12.6 s. The actual time should be controlled within the beat of the assembly line, therefore these two stations should be improved. After much debate and test for power testing station, its time has been declined to 6.38 s, so that the total operation time of this station reach to 9.98 s; too much to the high-voltage test station, plug the power cord included in operating can be canceled, and below the conduction electrons through the high voltage power supply, so that the collector plate flow to next station directly with the high-voltage power supply. The station's total operation time has been optimized to 7.7 s.

Table 29.1 The operation time of assembly line in middle

Serial number	Workstation name	Operation time (s)
1.	A warm-up before functional testing	9.57
2.	AUTO LEVEL	9.6
3.	White balance adjustment (3 person)	29.76
4.	B\U test	8.56
5.	Power testing	12.6
6.	Color bands to confirm	8.94
7.	High-voltage testing	12.6
8.	Analog DDC burned into	8.7
9.	Digital DDC burned into	8.7
10.	Screen to confirm	9.6
11.	Finished function confirm	9.6

29.2.2 Heuristic Balancing Design in Assembly Line

a. The heuristic balance method

Heuristic balance method is a list of computation method that according to the operating element and priority map, its benchmark is the beat. Procedure of balance is as follows (Shen et al. 2008; Jin and Wu 2003):

(1) Determine the beat time, calculate the minimum required number of workstation;
(2) From the first station, the operation is distributed in order. The distribution of operations according to the priority map from left to right;
(3) Before each allocation, using the following criteria to determine which operation qualifies assigned to a workstation: Priority operations have been assigned;
The work time is not longer than the idle time of the station. If no qualify operation, continue to the next workstation;
(4) Consider the constraints of equipment layout to determine a suitable operation;
(5) When an assignment is over, to calculate idle time, idle time is equal to the beat minus the total operation time of the workstation;
(6) If two operations are same situation, one of the following methods should be selected:
Assign the longest processing time;
Allocation the most of follow-up operations;
(7) Continues until all works are assigned;
Heuristic method has two principles: first, to analyze bigger position relative weights of operation; the second is the analysis of compatible of the operating element. The assembly line is in a good state of balance if each station operating time is equal, if they are not equal, there is wasted labor.

If you are using a common heuristic balance in balancing process, it is not difficult to find: Suppose a station idle time is 11 s, while operation time of next station is 12 s, the operation will be transferred to next workstation due to operation time is greater than idle time, but the number of workstation cannot increase, it will result in the first few stations to take time lower than theoretical beat time, and then several workstations are much larger, which will cause a new imbalance of assembly line. To solve this problem, when the operation time is longer than the idle time of the station, comparing beyond time and idle time, it will as be the station last process which closest to the ideal beat time. The goal is to ensure that operation time of each workstation in total assembly line is closer to the ideal beat, that is, each work center synchronization, this is improved heuristic balance algorithm (Yang 2010; Lu et al. 2009) *b. The improved heuristic balance design*

(i) Unbalanced assembly line parameters
Operation time of each station is obtained by field-tested, to determine bottleneck of the assembly line by comparing these time, the time of the bottleneck link as beat, calculate the other relevant parameters. Assembly line beat C = 10.5 s, the number of workstations N = 46, the total number of assembly line operators S = 54, the total operation time T = 459.44 s, Production capacity P:

$$P = \frac{worktime\ of\ everyday}{C} = \frac{8 \times 60 \times 60}{10.5} = 2753(unit)$$

The company practiced eight hours per class, two-shift rotation, so each line daily production of 5506 units, 14 lines per day for 77 084 units.

The efficiency of unbalanced assembly line η:

$$\eta = \frac{T}{C \times S} = \frac{459.44}{10.5 \times 54} = 81.34\%$$

Mechanized assembly line balancing efficiency should not be less than 75 %, mainly manual assembly line should be more than 85–90 %, only 81.34 % of the efficiency of this assembly line, due to some of the need to further balance design (Yang et al. 2011).

(ii) Design in improved heuristic balance method
When improved heuristic method is used in the balance of assembly line, it should be done to draw a map of assembly operations sequence, list the operation time unbalanced, and a theoretical beat is determined by capacity, then the heuristic method with improved allocate operation from the first workstation, allocated under the premise that satisfy the constraints as much as possible operating element to this station, until no operation can be redistributed, the end of distribution of this station; then assign the second station, the third, the fourth station operating elements etc., until all operating elements are allocated. The production capacity, the beat and the efficiency of assembly line balance should be calculated when all stations are allocated.

According to the proposed hourly output target of 350, can be calculated the ideal beat C (Tang et al. 2009; Yu et al. 2010; Becker and Scholl 2006).

$$C = \frac{per\ hour\ of\ work\ time}{per\ hour\ of\ output} = \frac{60 \times 60}{350} = 10.29\ (s)$$

The number of assembly line workstations cannot increase, by reducing the idle time so that each workstation in a busy state. You can improve the production capacity of assembly line by completing the most operation for every workstation. Balance the assembly line process, the operation time of each station is equal to or close to the theoretical beat, as far as possible to eliminate the imbalance. Sometimes there is redistribution for some station operations, too long for some operations can be properly decomposed of different position to achieve (Luo 2006; Hou et al. 2011; Liu et al. 2003).

By balancing assembly line, the longest operation time is the power test station, it is determined the beat of assembly line, it is C = 9.98 s, the number of workstations N = 44, the total number of assembly line operators S = 52, the total operation time of assembly line T = 457.44 s, production capacity of every day:

$$P = \frac{worktime\ of\ everyday}{C} = \frac{8 \times 60 \times 60}{9.98} = 2885(unit)$$

The implementation of eight hours per class, two-shift rotation, each line daily production of 5770 units, 14 lines per day for 80780 units.

The efficiency of balanced assembly line η:

$$\eta = \frac{T}{C \times S} = \frac{457.44}{9.98 \times 52} = 88.15\%$$

29.3 Analysis of Difference in Balance Before and After

To analyzing and counting operation time and idle time of each workstation, and draw on imbalance difference map of workstation before and after balance operating as shown in Figs 29.1 and 29.2. The horizontal axis is workstation of the assembly line, the vertical axis represents the operation time (unit: s).The bar columnar appearance two parts of a different color, the lower half of a dark-colored region, said the assembly line workstation standard operation time, the light part of the upper half is idle time for each workstation.

It can be seen from Fig. 29.1 that operating bottleneck work time in unbalanced assembly line is 10.5 s, assembly line product one LCD monitor in 10.46 s, the workstation operation time with significant differences. But the operation time has been improved, and idle time has been reduced in Fig. 29.2.

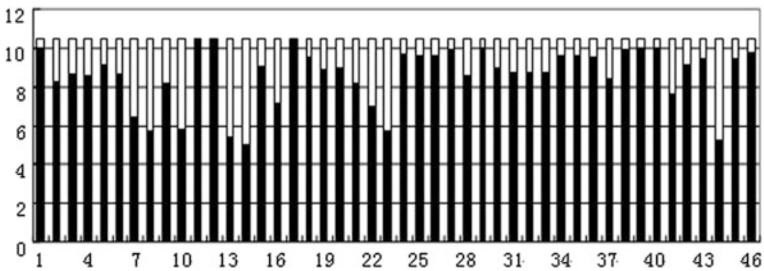

Fig. 1 Unbalanced station operation time imbalance difference map

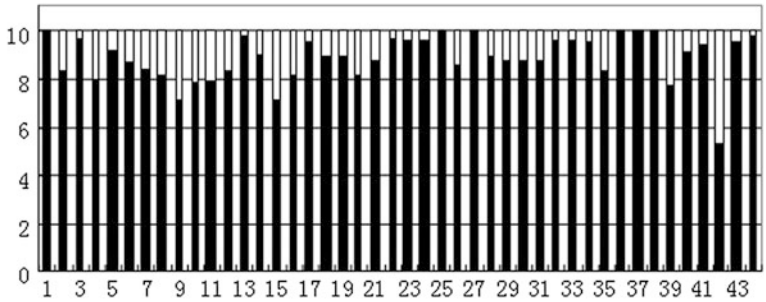

Fig. 2 Balance station operation time imbalance difference map

29.4 Conclusion

After balance design for LCD display assembly line use in improved heuristic balance, the takt time was compressed from 10.5 s decreased to 9.98 s, and the staffs working in assembly line were decreased from 54 before improving to 52 at present, the number of assembly workstation was reduced from 46 to 44, the production capacity by 5506 units daily to 5770 units; the efficiency of the assembly line balance from 81.34 to 88.15 %, reaching the targets developed by the enterprise, which proved that the method was suitable to the balanced design of the target LCD display assembly line.

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Chapter 30
Research on Framework Model of Real-Time Scheduling System for Cluster Tool Controller

Rui Lu and Lin-ying Li

Abstract On the basis of research on CTC (Cluster Tool Controller) software framework and SEMI (Semiconductor Equipment and Materials International) standard, the real-time scheduling system model of CTC, which consists of supervisory control level and module management level, is proposed. The supervisory control level is an abstract one, and is in charge of controlling schedule logic. According to principle of separating logical and function, a scheduling control logical model based on Extended Finite State Machine is proposed, as well as its control procedure under normal and exception conditions. In level of model management, task is breakdown in accordance with SEMI CTMC standard. At last, by analysis of test and verification of real-time scheduling system, the proposed model is verified using the idea of "virtual control".

Keywords Semiconductor manufactory · Cluster tool controller · Real-time scheduling system · Cluster tool module communications · Extended finite state machine

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30.1 Introduction

Cluster tools combine several single-wafer process modules and transport modules such as robots, and are widely used in semiconductor manufacturing industry and LCD production line. CTC is distributed control software system that communicates with the local module controllers (MCs), monitors events and state changes at the component modules, determines the scheduling and control commands in real time, and sends control commands to the MCs. Real-time scheduling system, which is in charge of monitoring information of equipments, as well as managing and coordinating resource of modules according to standard communication protocols, is a key part of CTC. Process Module Controller (PMC) and Transport Module Controller (TMC) are distributed entry that provides with SEMI (Semiconductor Equipment and Materials International) standard services and control wafer processing and transferring function. In other words, real-time scheduling system is a superior conductor, and be in responsible for acquiring working information of each module controller and giving proper control command.

There have been some relative researches on CTC real-time scheduling system. Lee and Lee (2004) proposed a CTC scheduling system framework based on field bus technology. Unfortunately, this module does not meet SEMI standard. TrackSim is applied to Track to evaluate performance of different input and dispatching rules (Hong et al. 2001; Li and Hu 2010). Shin et al. (Shin et al. 2001) presented a CTC system real-time scheduling system framework and proposal methods for the exception of equipment failure and communication delay. ClusterSim system provides with detail statistical reports. ToolSim system is ClusterSim's upgraded version, and be applied to estimate the throughput of chemical vapor deposition (CVD) at Texas Instruments' DMOS 5 wafer fabrication. The Single Wafer Processing (SWP), which is developed by Samsung Company, is a real-time scheduling ways to test temporary wafer processing (Kim et al. 2009). Huang and Hsiao (2002) proposed CTC control software based on Petri net for the use of remote diagnosis and advanced process control. However, they did not analyze scheduling control logic. All the researches mentioned above do not coincide with SEMI standard and its effects have great differences with actual conditions.

The rest of this paper is organized as follows. In Sect. 30.2, the framework model of the real-time scheduling system is presented. The supervisor control layer is designed based on the extended finite state machines in Sect. 30.3. In Sect. 30.4, it is implemented for the module management layer based on cluster tools module communications. System validation and test is addressed in Sect. 30.5. Lastly the conclusions are given.

30.2 The Framework Module of Real-Time Scheduling System

30.2.1 Cluster Tools

Cluster tools combine several single-wafer process modules and one wafer transport module. Process modules are used to process wafers, and transport modules are responsible for transferring wafers between process modules and cassette modules. Process modules can be set to difference procedure, and also be easy to change. Process flow can be changed according to different wafers. Therefore, cluster tools are referred as reconfigurable manufacturing system.

Cluster tools are similar to m-stage no-wait flow shop. Same types wafers are transferred into input cassette, and then be picked by robot into process modules after being located by video system. Wafers are processed in sequence and be cooled, at last be transferred back to output cassette. Figure 30.1 shows cluster tools with four process modules and one dual-arm robot.

30.2.2 Real-Time Scheduling System Framework

The research and development of CTC control software is a complex engineering system. It requires cross development of several subjects, such as control, mechanics, electronics and informatics. The propose is to effectively control and schedule entire system, which is the important and difficult point of system development and realization. In this paper, the function of scheduling and control in different hierarchy is separated and unified into a real-time scheduling system

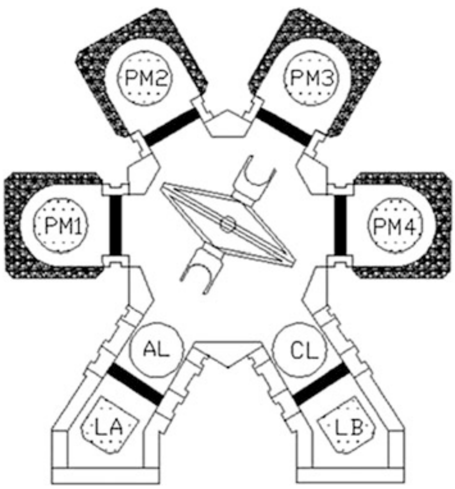


Fig. 30.1 Cluster tools

framework model, as showed in Fig. 30.2. According to different hierarchy, the model has a supervisor control layer and a module management layer. The supervisor control layer determines scheduling command by means of finite state machine and then reacts to returned events. The module management layer is used to transform command of superior layer into several concrete commands that coincide with CTMS standard.

The test and verification of real-time scheduling system uses various module controllers. This layer should applied simulation technique to simulate actual process of TMC, PMC and Carrier Module Controller (CMC). The PMC is responsible for controlling process device and pallet, TMC robot and slot valve, CMC control cassette and atmospheric robot.

30.3 The Supervisor Control Layer of Real-Time Scheduling System

Supervisor control layer is realized by real-time scheduling control logic of CTC control software. The scheduling control logic reads task table so as to determine control commands. Task table consists of transport task and process task which is generated by scheduling decision. According to process recipe and wafer flow model, process engineer calls algorithm exiting in scheduling algorithm library, and generates scheduling decision. The function of scheduling control is described as follows: (1) In order to make modules coordinate smoothly and to process wafer according to assigned recipe, the superior control commands are determined for every state change of system or every event aroused by module controller. (2) Determining the sequence and time of place, pick and movement. When process module or transport module finished a task, scheduling command is send

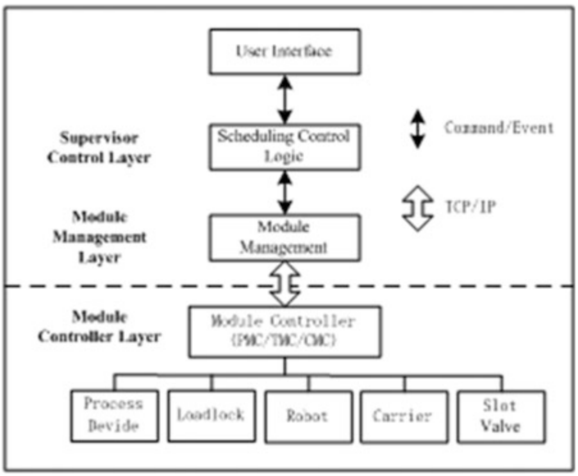


Fig. 30.2 Real-time scheduling system framework model

to module controller through module management layer. (3) Processing the control process of events. The events include breakdown of parallel module, random auto-cleaning of PM, overrunning of hold-up time. The supervisor control layer uses finite state machine to describe scheduling control process of devices. It helps to separate logic control and function (protocol) of device, so as to made device be reconfigurable, and to satisfy the requirement of recipe and frequently change of wafer flow model.

30.3.1 Extended Finite State Machine

Finite state machine consists of finite states and its mutual transfer, and only be in one certain state at anytime. State machine generates an output when it received an input event, at same time, it is possible to change to other states (Shun et al. 2007; Shi et al. 2008).For a complex system, such as CTC control software, there will be thousands of states if it applies the above FSM model, and results to low effectiveness and difficulty of verification and maintenance. The hierarchical FSM is organized hierarchically by a serial of basic FSM. One or several inferior FSM corresponds to one state of superior FSM. When FSM was in a certain state, one or several inferior FSM may process in parallel or sequence way. It can realize structured and hierarchical expression of system behavior by means of using hierarchical FSM to model behavior.

In order to solve the above problems and to effectively describe dynamic redundant behavior of CTC process and transport model, EFSM model (Liu et al. 2011; Liu and Yang 2008), which is extended from traditional hierarchical FSM, is generated. Due to introducing inter-parameter and adding meaning of transition function, it is not difficult to avoid increasing of states caused by complex system function, so as to effectively increase the number of states and to abbreviate state explosion.

30.3.2 The Scheduling Control Logical Model Based on EFSM

The scheduling procedure of real-time scheduling system is coordinating relationships between process model and transport model. The process task of process model depends on transport robot's placing and picking task. Therefore, the act of transport model plays a dominant role in the modeling strategy and determines acts of process model. In order to utilize EFSM to model periodic cycle process of process model, the state number of EFSM is decreased, and complex of EFSM model is simplified; information table is also introduced to record parameters of wafer processing. When the system recipe is changed, such as adding or cutting device, introducing new recipe or control algorithm, EFSM updates processing state by means of searching new task information table, so as to avoid duplicating modeling, and then realize re-configurable. For example, the process step 10 in Table 30.1 consists of two process model, PM1,1 and PM1,2. Its process recipe is Recipe A, while auto-cleaning recipe is Clean Recipe A. The next transport object of dual-arm robot is wafers in PM1,2 (○ represents the wafer in processing, while ● shows the next wafer to be transport). The process phase (consists three state: initial, steady and final) is in the state of steady. The pre-state of step 10 is in initial.

According to schedule resources, process procedure is classified as process model, transport model and wafer. As the processing object of process and transport model, the state of wafer in different process steps is only determined by state machine of process and transport model. Therefore, wafer state machine is not considered by real-time scheduling system. Here is description of state machine of process and transport model. Figure 30.3a shows EFSM model of process model. When EFSM model received pick completed event (Ev_Pick_Completed), model is in the state of ready (Camber Ready); when EFSM model received place completed event or swap dual-arm completed event, model is in the state of Wafer Ready. Then process model downloads recipe from CTC recipe space by recipe executor, and starts wafer process. The wafer will wait for picking by robot after being completed (Ev_Process_Completed). It can be seen from task information table that the current system is in the state of steady. The state machine of process model starts process wafer periodically.

Figure 30.3b shows state machine model of transport model. When system is in steady state, robot applies swap operation to complete wafer transport task. When it is in the state of initial or final, robot uses picking or placing operation to transport wafer. That is to say, transport task is completed by means of pull strategy of single-arm robot. Shin et al. (2001) give scheduling control logic of CTC control software based on FSM. Unfortunately, only the situation of steady state, not the state of initial and final, is considered by them.

There are many exceptional situations, such as malfunction of process model, auto-cleaning, temporary wafer processing. The exception handling function is embedded in the state of EFSM model. It is possible to handle accident situation according to defined procedure, and to determine whether to re-schedule system.

Table 30.1 Task table

Process step	Process model number	Phase	Recipe	Clean recipe
10	PM1,1○; PM1,2 ●	Steady	A	#A
11	PM2,1○	Steady	B	#B
12	PM3,1○	Steady	C	#C
13	PM4,1○	Steady	D	#D
……	……	……	……	……

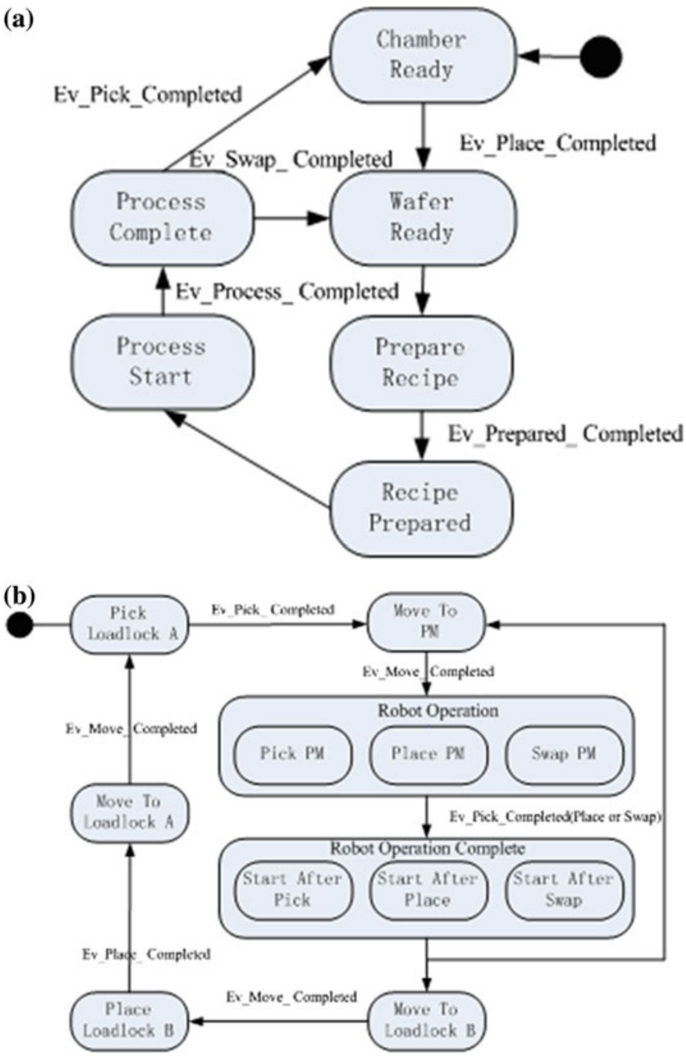


Fig. 30.3 Scheduling control logic model, **a** EFSM model of process module, **b** EFSM model of transport module

30.4 The Module Management Layer of Real-Time Scheduling System Based on CTMC Standard

Scheduling control logic model produces superior control command (task) which will be separated to scheduling tasks. Module management layer is logically separated into two levels: (1) separating superior task into more detailed scheduling task; (2) communicating with inferior model control layer according to CTMC standard.

30.4.1 The Procedure of Task Separating

Figure 30.4a and b shows the separating procedure for process and transport task separately. Process model completes a serial of periodically operation, that is, chamber ready (chuck is moved up and be ready to accept a wafer) → wafer ready(slot valve is opened) → closed(slot valve is closed) → wafer completed(chuck is moved down and be ready to process wafer) → ready(reading process recipe) → processing(starting processing). Process model accepts control command from scheduling control logic, so as to complete every operation steps, and to send success or failure response to scheduling control logic. Transport model also completes operations: ready → wafer ready (slot valve is opened) → performing robot placing, picking operation or swapping dual-arm → closed (slot valve is closed). In Fig. 30.4, the events or commands above symbol → consist of two or more correlative parameters, such as lot number, wafer number and process model number, et al.

30.4.2 Task Operation Based on CTMC

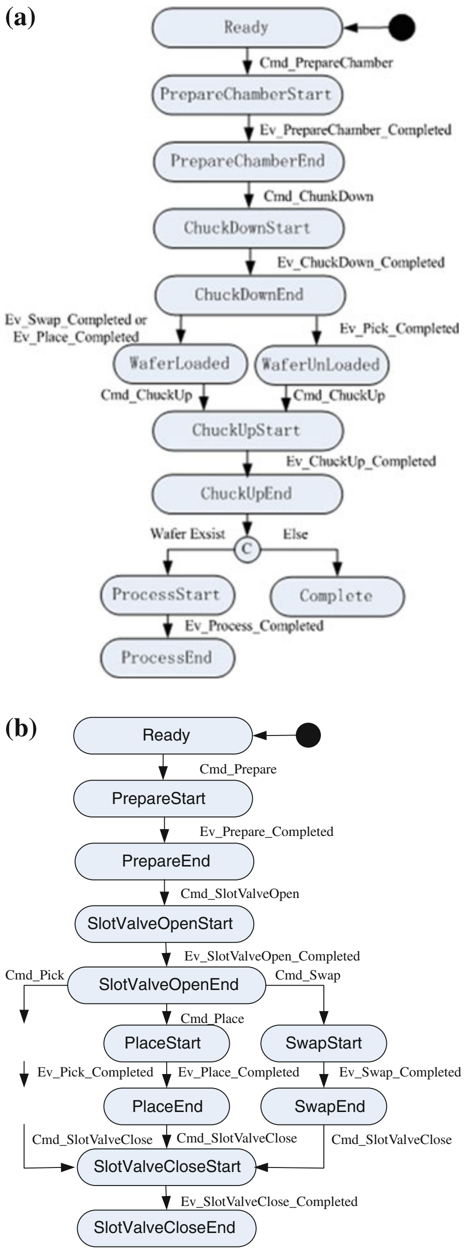
SEMI E38 CTMC is communication service standard between CTC control software and model controller. It consists of material transport management (E32), object service (E30), technological process management (E40), exception management (E41), recipe management (E42) and event report (E53). CTMC defines information model, object and communication service needed by CTC monitor and coordinate module controller.

In real-time scheduling system, object-oriented technique is used to design object in compliance with CTMC standard. For example, TRJob object is used to describe material transport management (shown as Table 30.2), while PRjob object is used to describe process model management. Due to material transport management plays dominant role in the period of task execution, we only introduce TRJob object.

Figure 30.5 shows procedure of describing Swap command according to TRJob object: TRjobCreate ("TMTRJob1", WAFER, "002", "001", "PM1SwapDomain", Swap). Req in phase 1 is a command sent to TMC to create transport task ("TMTRJob1") and swap the wafer (002) being operated by robot and the wafer (001) in process model (PM1SwapDomain); the returned event TRJobAlert ("Ready") represents TMS is ready. In the same way, PMC1 in phase 2 does similar operation. As client, PMC1 in phase 3 start hand-shake confirm to server TMC1 to determine whether wafer has been placed or picked by robot. At last, TMC and PMC1 send messages ("TRJobComlete") to CTC separately.

CTMC standard is high-level application protocol. TCP/IP layer applies SECSII/HSMS protocol to complete low level data communication. The content in every TRJob member function will be coded as SECSII protocol format, and then

Fig. 30.4 The decomposition procedure of process and transport task, **a** process module task, **b** transport module task



be sent to module controller. Module controller is charge of decoding protocol data to format of CTMC object. Subsequently, module controller executes command then returns response event.

Table 30.2 TRJOB object

	Name	Specification
Attribute	ObjType	Object type:TRJob
	TRJobID	Job ID
	TRJobType	Material type
	TRJobName	Material identifier
	TRSwapObjName	Identifier to be swapped
	TRPartner	Identifier to the source
	TRPortID	Process module indentifer
	TRCommand	Task to be performed
Function	TRState	State of transport job
	TRJobCreate	Create TRjob object
	TRJobCmd	Command
	TRJobAlert	Notifcation

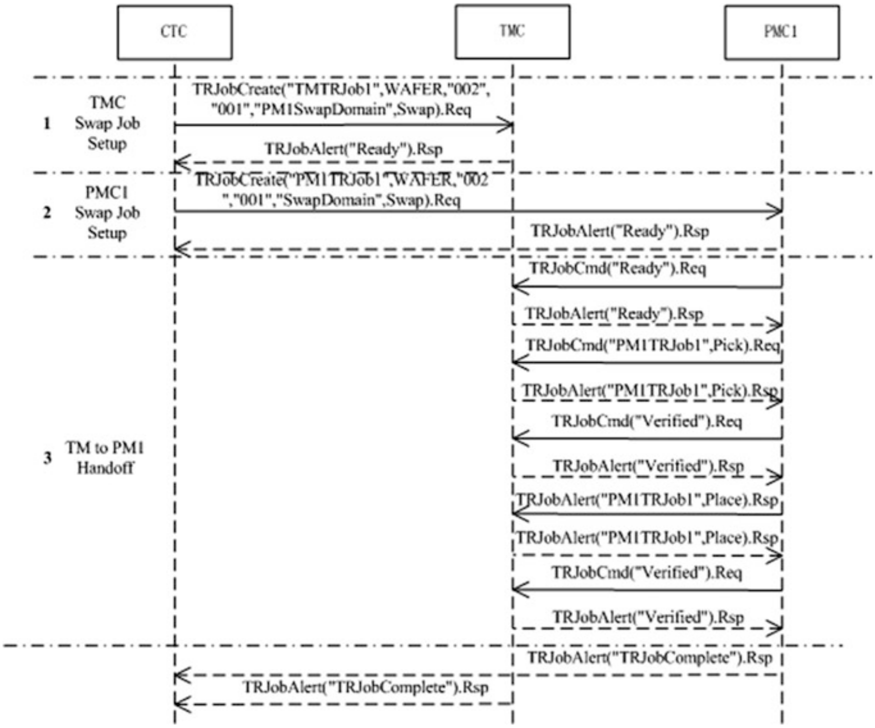


Fig. 30.5 The execution process of swap

30.5 Testing and Verification

The meaning of virtual control is used to test and verify the real-time scheduling system. It needs to complete functions as followed: (1) developer is able to designate test scenario of operation machining cell and transport cell; (2) like actual operation of PMC and TMC controller program, simulation model management program is in compliances with CTMC standard, and construct test and verify system according to integrate communication module management program and real-time scheduling system; (3) module management has CTMC communication interface; (4) providing proper analysis tools to satisfy developer to recognition error, analyzing and statistic from different aspect.

Figure 30.6 shows the test and verification system developed according to principle of virtual control. The details of every part are described as followed.

(1) Testing scenario: users could define wafer process pattern and number of processing wafer, and simulate the scheduling process for a batch of wafers, or sent command to model controller by means of manpower. These commands consist of processing command, transport command, downloading recipe command, exception exist and stop command, et al.
(2) Module management program: according to different communication objects, the finite state machine driven by network event could provide automatically connection, time-out disconnection for communication client and server; and decode SECSII format sent by CTC to message event needed by module controller, change state of module controller machine, and return message as format of SECSII.

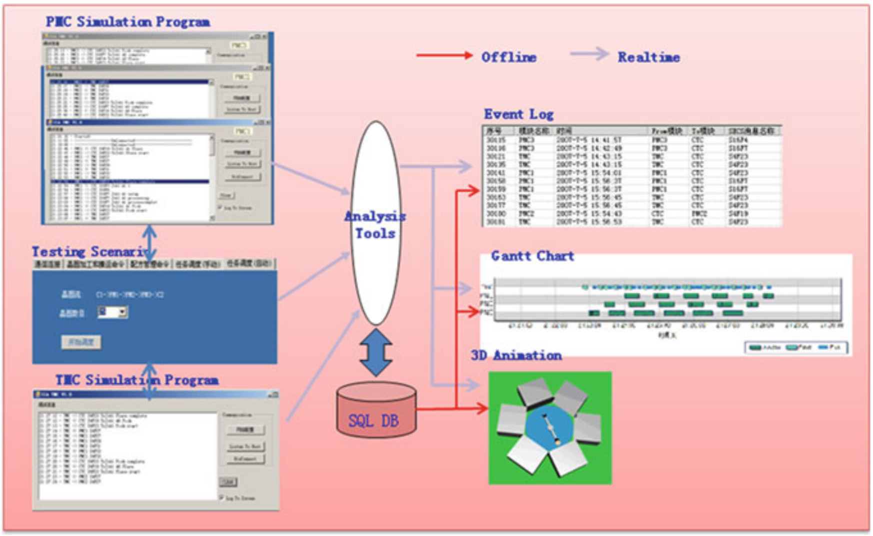


Fig. 30.6 Testing and verification system

(3) PMC and TMC simulation program: simulation object create model by means of UML state diagram and sequence diagram. When it received control command from CTC, or internal events of processing complete/alarm, simulation object changes its state according to protocol standard. PMC and TMC simulation objects have same parent class. The only difference is number function and internal logic after extended from parent class.
(4) Analysis tools: PMC and TMC simulation program trace event message driven by a certain of scenario. Messages are stored in relevant tables in Microsoft SQL, and be sent by Socket interface to industrial computer that exists analysis program, so as to generate event log.

30.6 Conclusion

On the basis of research on SEMI standard, a framework model of real-time scheduling system based on extended finite machine is presented in this paper. The proposed model consists of two layers: supervisor control layer and management layer. The character and development process of test and verification of CTC control software is described. Testing scenario, module controller and analysis tools are generated to realized the principle of “virtual control”. Thereby, verification workload is decreased in the period of development. Error detection in later period and development cycle of system are also decreased too. So the proposed system has practical significance and application value.

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Chapter 31
Application of Remote Network Control Based on Internet for a Kind of Improved Shiplock of Port

Zhong-qing Cheng, Ke-nan Ge and Hai-bo Jiang

Abstract This paper introduces an improved shiplock of pork and suggests a kind of model system in shiplock which adopts internet and global system of mobile communication technology. The model system realizes networking automation control of multishiplock and solves the shortcomings of the traditional monitoring. Based on these concepts, it further achieves remote monitoring with unattended operation through phones' video by high speed data transmission technology.

Keywords Shiplock of pork · Automation control · Video data transmisson technolegy · Remote monitoring · Model system

31.1 Introduction

Along with the rapid development of science and technology, the prevalence rate of mobile phone is getting higher and higher. Because of broad coverage of the wireless network for cell phones and stable, reliable transmission in information, they are used as carrier of information transfer. The application system which made up of single chip micyoco (SCM), global system for mobile (GSM) module, surveillance cameras and phones has strong vitality and broad application space. Especially in the remote data transmission and remote monitoring fields, it attracts a lot attention of electronic design engineers (Wang and Liu 2009).

On the other hand, with the rapid development of the water conservancy project, the direction of development is being transformed into intensification and scientificalization. Scientific monitoring and remote control is a very important link of water conservancy project to face the increasing project scale. The

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traditional water conservancy system detection is based on a single shiplock for the unit. If we use the same method to monitor multishiplocks of intensive scale water conservancy systems then that will be a large number waste of time and fund, the monitoring effect is not satisfied either (Mo et al. 2000). Meanwhile, constructions of water conservancy projects in very bad natural conditions will take a lot of dangers and troubles especially when technicians execute the operation control on the spot. The situation when several shiplocks with unattended operation in a short time will likely happen. These entire problems which existed should be solved.

The realization control of remote monitoring and management for the shiplock can improve the situation. We can make scientific scheduling and decision through signal transmission of water level and other environmental factors in shiplocks.

31.2 Total Design Solutions

The improved mechanical structure and remote control system is used to optimize the whole efficiency of ship locks. The total design solution is to make the system more intelligentized and humanized which contains the follow parts.

31.2.1 Remote Monitoring Design

The remote control system is based on microprocessor to make process centralized supervising and dispersed control (Shi 2008). The terminals is used in dispersion process control by the system, all information is monitored and controlled through the communication network by the management of the center computer which can be visited by PC client and mobile terminal at the same time. Mobile phone and GSM modules are connected through the GSM network, GSM module is connected with control center. PC client and control center have the direct connection through the internet. The structure chart of system is shown in Fig. 31.1.

Mobile terminal and the PC client can access and control all shiplock hoists, sensors and cameras with the help of control center. At the same time each part can also give a real-time feedback to each client through the control center. All parts and control center are connected through the master hubs which realize data acquisition, decentralized control and concentrated surveillance.

31.2.1.1 Structural Design of Master Station

The master station of microprocessor finishes the data presentation. The microprocessors which control GSM module realize the communication of users. The master station of microprocessor is communicated with upper computer through serial ports. Data storage is completed by the upper computers which connects

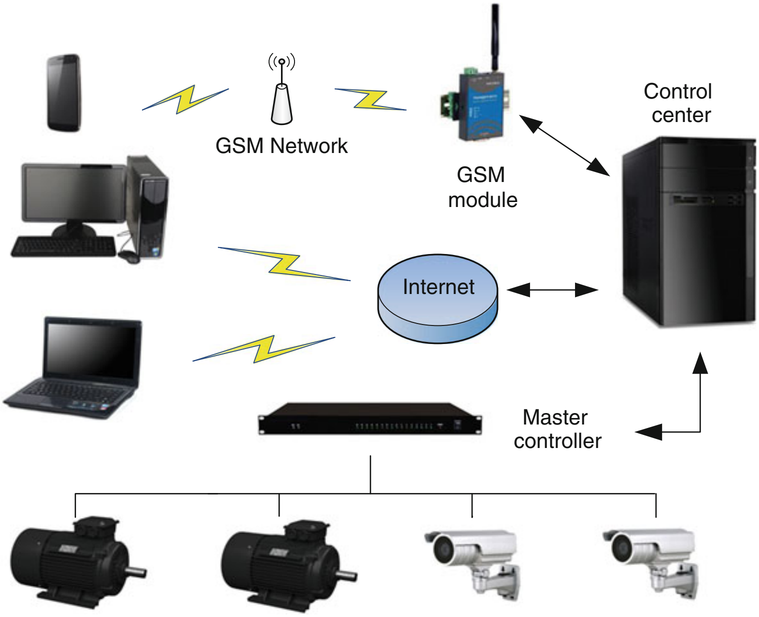


Fig. 31.1 Structure chart of monitoring and control system for shiplock of port

with remote computer through network then finish the establishment of monitoring network. The upper computer can also send warning signals and control the hoists, cameras and other monitoring equipments (Ge 2000).

The operator can monitor the shiplock more easily through remote network which realize remote computer control. Both PC client and GSM module can transfer the signal information to master station of microprocessor and control the monitoring equipments through relays of ports.

To use the function of monitoring and management,the operation station of PC client must provide the follow equipments: operating platform, microprocessor system, external storage and graphic display device. The mobile terminal must support high speed data transmission technology that further achieves remote monitoring with unattended operation through phones' video.

31.2.2 Software Design of GSM Technology

31.2.2.1 Remote Quantitative Control of Shiplock Switch Through Mobile Terminal

The module and mobile terminal which control locks use GSM technology to manage stepper motor. This system can effectively reduce water conservancy system daily management cost. Wherever mobile coverage has can realize real-time monitoring of the shiplocks, convenient for operator to visit (Mao 2008). Through the GSM module, operator can realize defined control of quantitative degree for locks. The system structure is shown in Fig. 31.2.

The GSM module of control center is responsible to run interaction for the operators in messages. Operators can know the site condition at any time and place where service network cover. The GSM module will run operations to the shiplocks according message instructions. Specific message process is shown in Fig. 31.3.

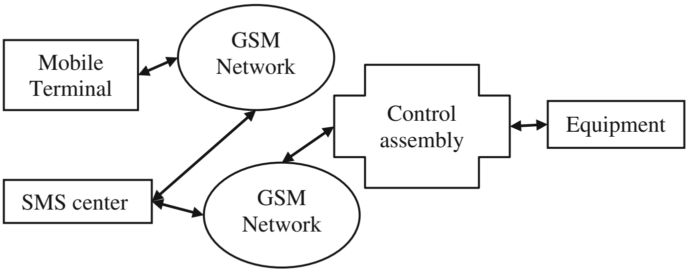
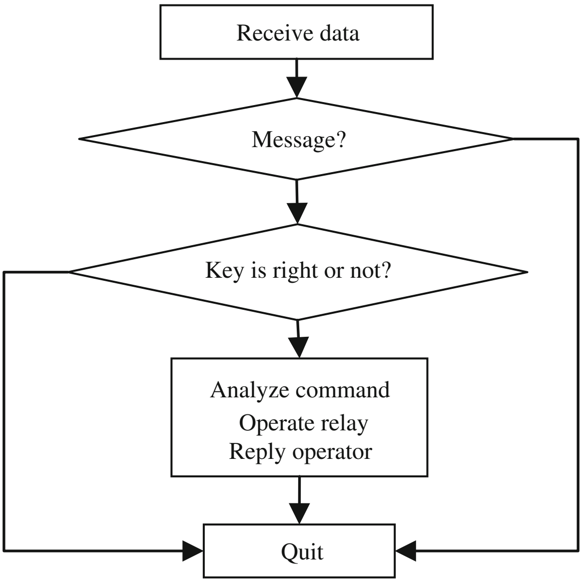


Fig. 31.2 System structure diagram of GSM work

Fig. 31.3 Message process flow diagram



31.2.2.2 Function and Using Method of Shiplock Control

There are three communication ways to send the control instruction. The first is that GSM module connects with center computer and use interface made up by VC to send and receive messages (Li 2005). The second is that using the function what mobile equipment provides. The third is that using single chip and GSM module through assembly language programming.

Set user permission and only defined mobile number can realize the control of shiplock; prevent other mobile terminal interference. If user permission has already been verified the system will work regularly. After system received command on or off the shiplock, stepper motor will get started. The motor open the shiplock with executive height according to the message sent by operator. System replies information which contains water level and locks' height after the locks operate.

Connect the computer with GSM module, and then we can achieve the same purpose to mobile control through the interface of computer. This system also set a manual operation which used for regular maintenance and system malfunction repair. The manual and automatic type can switch at any time.

31.2.2.3 Video Monitor of Mobile Terminal

We use high speed data transmission technology of mobile phone combining with the function of cameras and transfer compressed video data from cameras collection to mobile terminal through the network. After decoding mobile phones can run real-time monitoring of the shiplock environment. In visual control mobile client don't need to use any application plugins. The analog signal acquisition from camera video is changed into digital signal through built-in processing system. This process realizes the remote monitoring function (Yang 2009).

There are three steps in video monitoring function which is shown in Fig. 31.4. First, establish video monitoring function through equipments. Second, connect cameras with designated workstation. Third, mobile terminals login the routing of workstation to visit the video.

This video monitoring system solves the question that several shiplocks can be monitored at the same time and the question when there is no operator on duty in short time. It realizes the function of monitoring and prevention of burglary for the port.

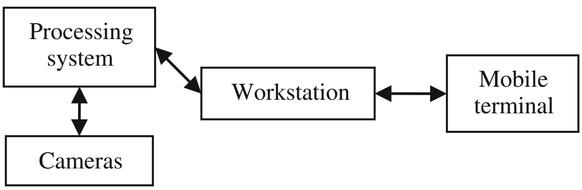


Fig. 31.4 Schematic diagram of mobile terminal monitoring

31.2.3 Structural Design of this Improved Shiplock

The common stationary gate hoists contains winch hoist, screw hoist and hydraulic hoist. The winch hoist has strong carrying capacity, flexible operation, fast speed and high cost. The screw hoist is simple and convenient at a low price. It applies to the condition that project is small, water pressure is big and weight of lock is not enough. The hydraulic hoist use oil pumps to make hydraumantic transmission. It gains big carrying capacity through lesser driving force. But it also costs a lot (Han 2001).

In this paper, we improve the structure of common shiolock to decrease driving force which reflected in two ways. One is that using adjustable balance lever based on lever principle. The other is that using the structure style of new electric push rod to decrease friction when shiplock opens. The main body figure of shiplock module is shown in Fig. 31.5.

In this improved shiplock module there are parts of lock gate, electrical machine, control box, water tank and water pump. The height of module shiplock is that $H = 0.13$ m, the normal upstream water level is that $H_1 = 0.08$ m, the normal downstream water level is that $H_2 = 0.015$ m, gate weight is that $G_1 = 0.56$ kg (Zhao and He 2005). For weight of balance nut is much larger than balance lever itself, we ignore the weight of balance lever. Every balance nut has weight that $G_2 = 0.22$ kg, adjust the biggest distance of balance nut to calculate the center distance between O_1 or O_2, $l_0 = 0.16$ m, $l_1 = 0.18$ m, $l_2 = 0.082$ m.

The Gear3 and Gear4 connected through conveyor belt bobbin by frictional force which is shown in Fig. 31.6, radii are $r_3 = 0.0195$ m, $r_4 = 0.0065$ cm. The linear speed of gears is equal in value and opposite in direction, the friction is equal in value and opposite in direction, too.

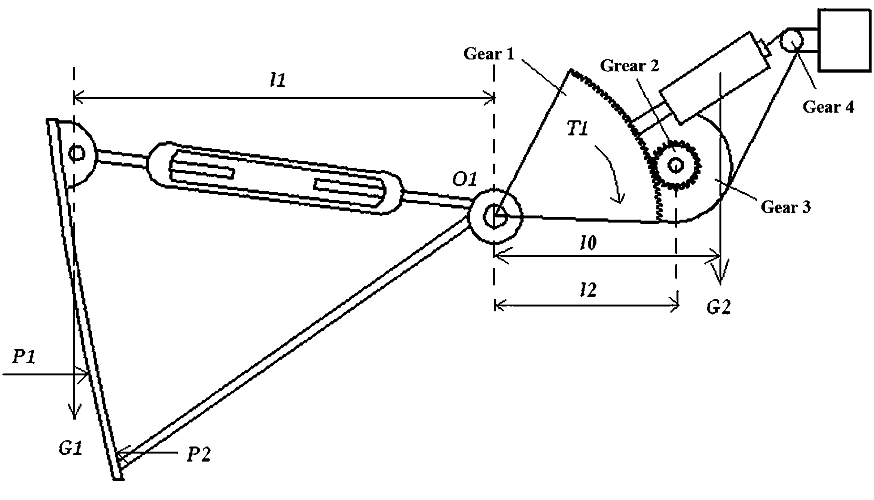


Fig. 31.5 Main body figure of shiplock module

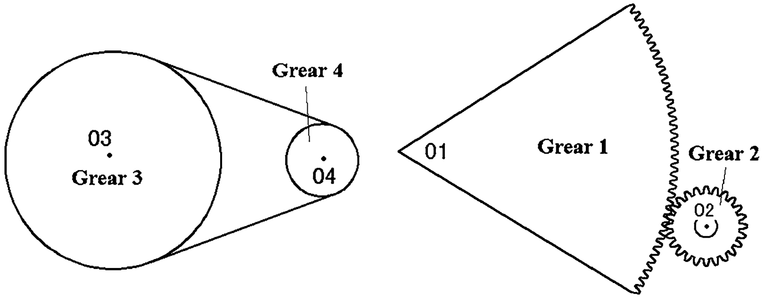


Fig. 31.6 Local structure of electric push rod and gears

Gear1 and Gear1 are straight toothed spur gears which have the same force of periphery at gear edge, so their torque and have diameters inverse relation. The follow equation can explain this d_1 and d_2 are diameters.

$$\frac{T1}{d1} = \frac{T2}{d2} \tag{31.1}$$

In this module, radii are $r_1 = 0.072$ cm, $r_2 = 0.01$ cm, so $T_1 = 7.2T_2$. Through the calculation, it is known that the force motor transfers to sector gear have increased 7.2 times. According to the principle of lever balance, the force T_1 given by sector gear from motor will balance the force which contains weight of balance nut G_2, gate weight G_1 and water weight (HIT theoretical mechanics staff room 2002). Then make the lock opening and closing come true. The simplified checking computation is shown in (31.2).

$$\begin{gathered} P1 = \frac{1}{2}\rho g H_1^2 = 31.36\text{N} \\ P2 = \frac{1}{2}\rho g H_2^2 = 1.10\text{N} \\ \sum M_{O1} = 0 \\ P1\left(H - \frac{1}{3}H_1\right) + G_1 l_1 = P2\left(H - \frac{1}{3}H_2\right) + 2T1 + 2G_2 l_0 \end{gathered} \tag{31.2}$$

The upstream pressure is simplified as P_1 by external load on gate, the downstream pressure is P_2, fulcrum is O_1, we calculate the data according to moment balance principle and get $T_1 = 1.57$ N, it is far less than gate weight. To sum up, the hoist power needed in this project is greatly reduced than traditional gate force.

31.3 Conclusion

This system uses dispersion terminals in process control. All information is managed by center computer through network to realize the optimum control. It concentrates management, operation and display. The system also realizes the segregation of function, load and danger.

The application of this project can be appropriate for not only in ports, but also in a vast territory or intensive river areas where it is inconvenient for operators in water conservancy or agriculture irrigation. Realize nonelectric wires, unattended operation, and multichannel control. The project can improve the management efficiency and save large resources and energy.

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Chapter 32
Life-Cycle Analysis on Acid-Gases Emissions of the Lightweight to Passenger Cars Using Aluminum Alloy and Advanced High Strength Steel

Li-sa Zhu

Abstract Nowadays, in order to reduce fuel consumption and tail gas emissions, the lightweight has been adopted in passenger cars. However, whether the fuel consumption and tail gas emissions including acid-gas can be reduced must be calculated from life-cycle. In this paper, acid-gas emission of normal and modified passenger cars has been calculated in life-cycle and more detailed stages on acid-gas emission have been analyzed.

Keywords Passenger cars · The lightweight · Acid-gas · Life-cycle

32.1 Introduction

In China, the population of passenger cars (PPC) has been increasing with drastic speed. In 1960, the PPC was only 230,000; and in 2000, the PPC has been reached 11,270,000 and almost has been increased by 50 in 40 years. Five years later, the PPC were nearly double and arrived at 20,500,000. In 2010, the PPC hit a new high and arrived at 62,040,300. It was estimated that the PPC will exceed 100 million in 2020.

With the wide use of passenger cars and the tremendous PPC, much acid-gas emissions have been emitted during the using of passenger cars. Supposing that a passenger car has been drive 10,000 km/year and drive 100 thousand kilometers before scrapping; and the amount of SO_2 are 0.295 kg in one year and 2.95 kg before scrapping. So In 2010, the SO_2 emissions by the PPC were 1802 ton. SO_2 is a main acidification gases, it can form acid rain and destroy building, forest and

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crops. Besides SO_2, there are also a lot of acid gases in passenger cars tail gases such as NO_2 and NO_x.

Based on mentioned above, the acidification caused by the PPC was very critical. So in order to reduce acidification gases, the lightweight to passenger cars has been adopted. The lightweight can reduce curb mass, oil consumption and acid-gases emissions of using stage, but acid-gases also have been emitted during other stages such as mineral mining, materials producing, and products manufacturing stages. So the analysis on acid-gases emissions must be considered from life-cycle, which will give the proper conclusions.

32.2 Literature Review

With the research progress of lightweight (LW) to passenger cars/vehicles, environmental, energy and economic issues aroused by LW have been studied. Kim et al. (2011) provided an assessment of vehicle LW with aluminum and high strength steel (HSS), and the assessment results show greater GHG savings derived from greater LW and added manufacturing costs as expected. Kim et al. (2010) compared the increase in greenhouse gas (GHG) emissions associated with producing LW vehicles with the saved emissions during vehicle use, and calculated that how many years of vehicle use are required to offset the added GHG emissions from production stage, and the result show payback periods for HSS are shorter than for aluminum. Kang (2008) pointed out that the development and application of advanced high-strength steels (AHSS) for automobile LW not only brings about significant emissions reduction and energy-saving, but also has advances of improved safety as well as recycling and reutilization. Waurzyniak (2009; Li and Chao 2009) have given the result that advanced materials for automotive manufacturing are helping automakers build lighter, more fuel-efficient vehicles, and related advanced materials property, including AHSS, HSS and aluminum. Masataka and Tesuharu (2007) have given these conclusions that magnesium substitution can save more life cycle energy consumption than the Al substitution, although magnesium ingot production consumes more energy than aluminum and steel productions; The use of recycled magnesium ingot in a high weight ratio is needed in keeping the life cycle energy consumption and CO_2 emissions low; Strength improvement in the magnesium alloy decrease total energy consumption and CO_2 emissions; if the body and hood are made of magnesium alloy and the ratio of recycled ingot is sufficiently high, the total energy consumption and CO_2 emissions will be markedly reduced.

From related articles mentioned above, the deeper studies upon LW to passenger cars/vehicles of energy and environment have been made. But acid-gas emissions were few studied.

32.3 Methodology

The proposed analysis method consist three steps: They are goal and scope definition, calculation model establishment, data collection. Particulars of each step are shown below.

32.3.1 Step 1: Goal and Scope Definition

In this step, a life cycle assessment application has been used to study acidification of the lightweight to passenger cars. The scope of this step is to calculate acidification of the lightweight to passenger cars in life cycle; and scope definition is divided into five stages:

1. Mineral mining stage;
2. Materials producing stage;
3. Products manufacturing stage;
4. Transporting stage;
5. Using stage.

In this paper, transporting stages only included materials transporting stage between different enterprises. So the acidification produced in internal enterprises was neglected (Xu et al. 2008).

32.3.2 Step 2: Calculation Model Establishment

In this paper, acidification calculation model has been established as below (Yan et al. 1999; Kekoleian 1993):

$$Acid_{total} = \sum Acid_i \quad (32.1)$$

where *Acid* is acidification of the lightweight to passenger cars in life-cycle;
i is from mineral stage to using stage.

32.3.3 Step 3: Data Collection

In this paper, four evaluating projects were constructed. They main parameters and acidification data are calculated by Eq. (32.1) and shown as Tables 32.1, 32.2, 32.3, 32.4 (Liu and Liu 2008a; Liu and Liu 2008b; Liu 2011). For the paper limited, only the detailed input and output data of project 1 and project 2 were listed in this paper.

Table 32.1 Main technologic and economic parameters of H passenger cars

Model	Curb mass (kg)	Crew size (person)	Oil consumption (L/100 km)	Material structure	
				Steel	Iron
4 × 2 Frontengine Frontdrive	1300.00	5.00	13.00	70	30

Table 32.2 Project 1 input/output (695 kg primary high strength steel body)

	Regular	Unit	Stages in life cycle				
			Mineral mining	Materials producing	Product manufacturing	Transporting	Using
Input	*Iron ore*	kg		16503			
	Scrap	kg		196			
	Manganese	kg		113			
	Limestone	kg		384			
	Dolomite	kg		666			
	Fluorite	kg		5			
	Iron mud	kg		219			
	Water	kg	241	281625.58	123956.15		
	Diesel fuel	kg	9.4		7	8.20	
	Gasoline	kg	1.87			0.94	21497.16
	Nature gas	m^3		4.27	263	76.71	
Output	CO_2	kg	615.07	3958.65	1829.98	454	68835.4
	CO	kg	301.21	35.08	0.15	0.02	5011.06
	SO_2	kg	41.08	35.08	0.15	0.02	5011.06
	NO_x	kg	19.63	3369.68	30.32	2.47	625.64
	C_xH_y	kg		499.20	0.08	0.04	987.39
	HC	kg	13.85	11.30			
	Dust	kg	198.76	266.24	9.77		
	H_2S	kg		1.10			
	N_2O	kg					

In Table 32.2, project 1 is basic passenger car, which body in white (BIW) was made by high strength steel (HSS) and curb mass is 1300.00 kg.

Project 2, 3, 4 are modified passenger cars, whose BIW were replaced with primary aluminum alloy, recycled aluminum alloy and advanced high strength steel and curb mass were 980.3, 980.3 and 1166.40 kg respectively. Oil consumption of using stage is calculated by Eq. (32.2) (Fig. 32.1).

$$Gasoline = \alpha M^{\beta} \ (\mathrm{L/100km}) \quad (32.2)$$

where

$$\alpha = 8.072;$$
$$\beta = 1.019.$$

Table 32.3 Project 2 input/output (375.3 kg primary aluminum body)

		Unit	Stages in life cycle				
			Mineral mining	Materials producing	Product manufacturing	Transporting	Using
Input	*Bauxite*	kg		6831			
	Soda ash	kg		195			
	Limestone	kg		891			
	Anthracite	kg		128.50			
	Baking soda	kg		41			
	Bay red mud	kg		2680.88			
	Carbon pole	kg		759			
	Cryolite	kg		22.10			
	Aluminum fluoride	kg		35			
	Calcium fluoride	kg		4.10			
	Magnesium fluoride	kg		5.50			
	Nacl	kg		27			
	KCl	kg		27			
	Water	kg		41068			
	Diesel fuel	kg	6.33				
	Anthracite	kg		53.5			
	Datong system of coal	kg		896.80			
	Matellurgical coke	kg		75			
	Heavy oil	kg		561.69			
	Nature gas	m^3		201.25			
	Electricity	KW.H	74.22	20027.81	434.48		
	Gasoline	kg					16775.74
Output	CO_2	kg	95.09	5923.66	407.56	344.72	53717.07
	CO	kg	0.12	490.12	0.02	0.015	3910.48
	SO_2	kg	0.12	108.78	0.48	0.41	6.88
	NO_x	kg	0.48	54.06	2.21	1.87	488.23
	C_xH_y	kg	0.01	0.22	0.06	0.03	770.53
	HC	kg	0.02				
	PM	kg	0.02				
	HF	kg		17.30			
	Dust	kg		42			

Table 32.4 Acidification (SO_2.eq kg) data of evaluating projects*

	MM	MP	PM	T	U	Total
Project 1	54.82	2417.94	24.57	2.27	446.70	2946.30
Project 2	0.46	146.62	2.03	1.72	348.64	499.70
Project 3		5.98	2.03	0.42	348.64	357.07
Project 4		42.41	129.19	1.01	405.64	988.25

**MM is mineral mining stage*
MP is materials producing stage
PM is product manufacturing stage
T is transporting stage
U is using stage

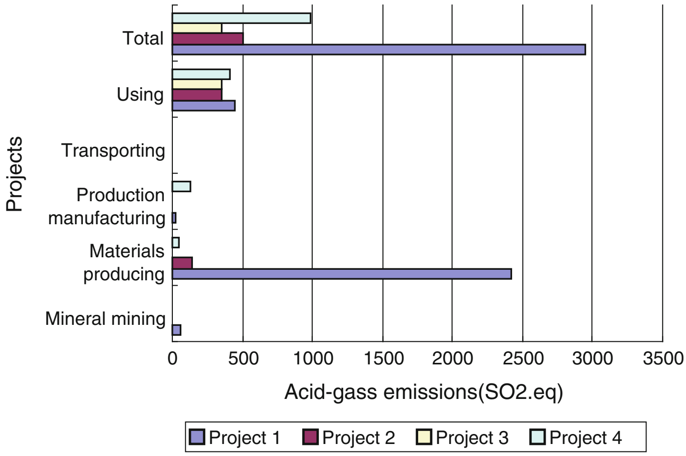

Fig. 32.1 Acid-gas emissions of projects

32.4 Discussions: Effects of Different Materials and Using Distance

This part included three contents: Effects of primary aluminum; Effects of recycled aluminum; Effects of advanced high strength steel (AHHS).

32.4.1 Effects of Primary Aluminum

Compared with normal project 1, project 2'BIW were replaced with primary aluminum and its life-cycle acid-gases emissions were reduced from 2946.30 to 499.70 (SO_2.eq kg). That mainly because that acid-gases emissions of project 2 were extremely reduced in materials producing stage. Concrete details were shown as Fig. 32.2.

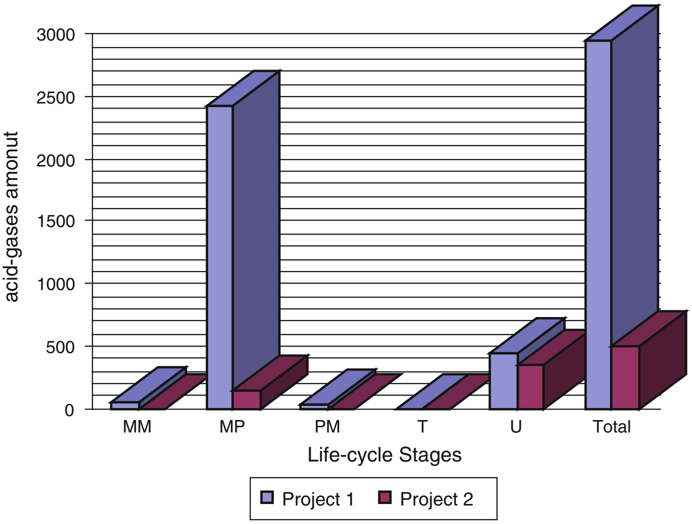

Fig. 32.2 Acid-gases amount between project 1 and project 2

32.4.2 Effects of Recycled Aluminum

Compared to primary aluminum, at materials producing stage, recycled aluminum can extremely reduce acid-gases emissions. But recycled aluminum has less effect on total acid-gases emissions in life-cycle of passenger cars. That mainly because the acid-gases emissions of using stage dominates the life-cycle acid-gases emissions.

As in developed countries, the ratio of recycled aluminum has surpassed 50 %. So in this paper, six recycled ratio of aluminum have been considered, they were 50, 60, 70, 80, 90, 100 % and details data were shown as Fig. 32.3.

From Fig. 32.3 that if the ratio of recycled aluminum can be reached 70 %, the amount of acid-gases emissions in materials producing stage can be reduced 98.45 (SO_2.eq kg) and if the ratio is reached 100 %, in materials producing, amount of acid-gases also can be arrived at “zero”.

32.4.3 Effects of AHHS

From Table 32.4, due to adopted AHHS, the amount of acid-gases on project 2 was second in all projects. That mainly due to the density of AHHS is higher than neither primary aluminum nor recycled aluminum alloy, which led to the amount of acid-gases emission is higher in using stage; and the amount of acid-gases emissions in product manufacturing is the highest in all projects. The specific results were shown as Fig. 32.4.

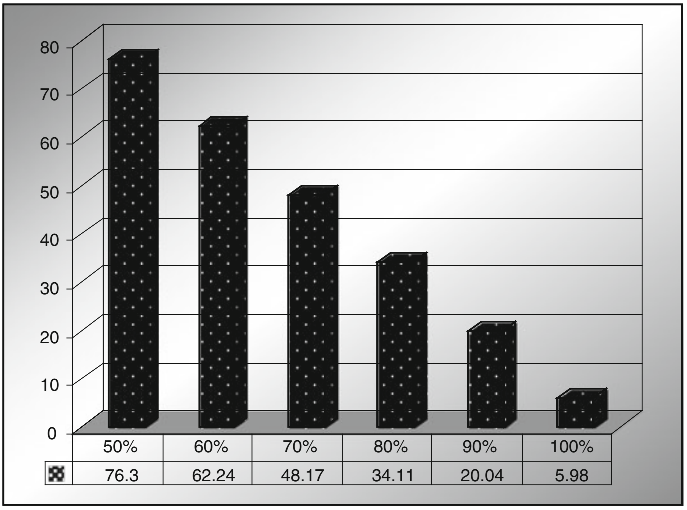

Fig. 32.3 Effects on acid-gases emissions of recycled aluminum ratio

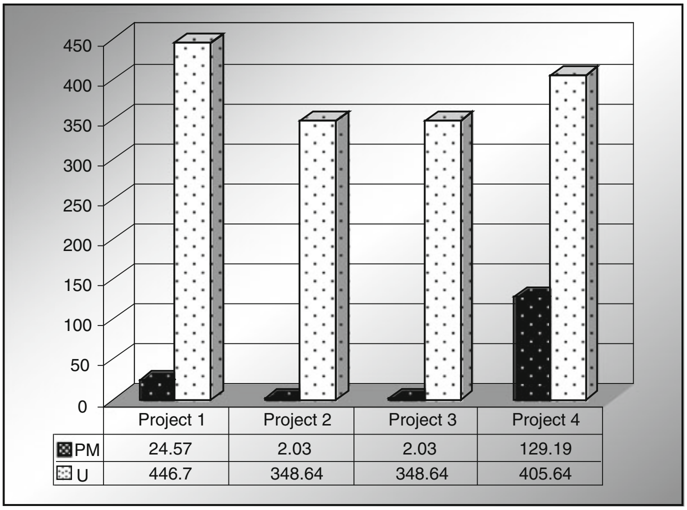

Fig. 32.4 The amount of acid-gases in product manufacturing and using stages of all projects

32.4.4 Effects of Using Distance

As to the most acid-gases emissions are emitted during using stage, it is essential to consider the effects of using distance. In this paper, the using distance is 200,000 km, and the sensitivity analysis of per 10,000 km must be calculated.

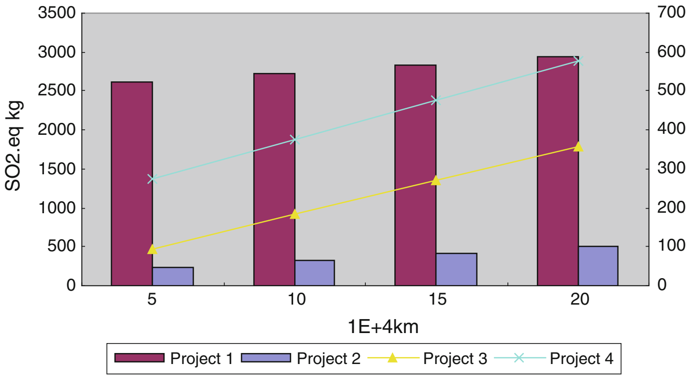

Fig. 32.5 Sensitivity analysis of acid-gases emissions

From Fig. 32.5, the sensitivity analysis results are as same as the life-cycle, that only because compared to using stage, the acid-gases emissions, in mineral mining, materials producing, product manufacturing and transporting stage, are very few.

32.5 Conclusions

From these studies, main conclusions have been achieved from life cycle as follows:

1. The acidification emissions of project 1 is the most in all projects, that means basic passenger cars emit acid-gas amount is bigger than modified passenger cars. That mainly due to basic passenger cars emitted more acid-gas in materials producing stages and should be given ample attention;
2. Applying recycled aluminum alloy can extremely reduce acid-gas emissions than primary aluminum alloy. That mainly due to acid-gas emissions can be reduced in materials producing stages by using recycled aluminum alloy. So in order to reduce acid-gas emissions, the ratio of recycled aluminum alloy must be height. Nowadays, the ratio of recycled aluminum alloy has been arrived at 50–60 % in developed countries, and the ratio is very poor in developing countries. So the potential of improving recycled ratio of aluminum is very tremendous in the word. If the conditions are permitted, the mechanism of recovering scrap aluminum should be built.
3. The acid-gas emissions of using AHHS is higher than using neither primary or recycled aluminum alloy, and that due to acid-gas emissions is higher in production manufacturing and using stages.

   Detailed results and conclusions have been shown as Fig. 32.1.

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A.1 32.6 Appendix

Appendix 32.1 Main ingredient of tail gas (g/L)

Ingredient	Weight
Ingredient of tail gas	
CO_2	2321.5
SO_2	0.295
CO	169.0
NO_x	21.1
C_xH_y	33.3
Acidification potential	
SO_2	1
SO_3	0.8
NO_2	0.7
NO_x	0.7
NO	1.07
HNO_3	0.51
NH_3	1.88
HF	1.6
H_2S	1.88
HCl	0.88
H_2SO_3	0.65
H_3PO_4	0.98

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Chapter 33
Evaluation of WMEP Disassembly Sequence Based on Entropy-TOPSIS Method

Wen-yong Zhou, Rong Rong and Yun-fei He

Abstract Better sequences need to be select when evaluating the disassembly sequences of waste mechanical and electrical product (WMEP), by which we can effectively improve the working efficiency and reduce waste. This paper establishes a comprehensive evaluation system for disassembly sequence, trying to provide a reasonable way to choose disassembly sequence. The model is designed based on entropy-TOPSIS, so as to improve the accuracy of evaluation, and simplify the complexity of the evaluation process. Before the end of this paper, a numerical example is conducted to demonstrate the feasibility and applicability of the model.

Keywords Disassembly sequence evaluation · Evaluation system · Entropy-TOPSIS method · WMEP

33.1 Introduction

Rapid development of modern industry leads to the growing demand of mechanical products. Mechanical products always face the cyclic process from using to abandoning, then recycling (Xu and Hai 2011; Wang 2006). Disassembly is an important part of green manufacturing as well as an essential way to realize resource conservation and sustainable development. Disassembly refers to the

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process separating parts, components and connectors from product (Liu et al. 2001). For waste mechanical and electrical product (WMEP), reasonable disassembly sequence can lower the cost, improve removal efficiency, and reduce secondary environmental pollution on disassembly process (Li 2010).

Most researches focus on disassembly sequence planning or disassembly model building. Their achievement enrich the current research, but unfortunately, the problem of evaluating disassembly sequences receives little attention (Zhang and Kuo 1997; Kang and Lee 2001). In practice, feasible disassembly sequence is not fixed, evaluating disassembly sequences and choosing a best one is very important. Most of present researches about the evaluation of disassembly sequences are more based on green design (Zhang et al. 2010). In addition, there are also researches employing AHP, fuzzy evaluation method, the gray relational analysis and other methods to evaluate the sequence of disassembly (Chang and Ning 2011).

Considering the background of remanufacturing, the evaluation of WMEP disassembly sequence is complex and multidimensional. While constructing a system of disassembly sequence evaluation, this paper puts forward a WMEP disassembly sequence evaluation model based on entropy-TOPSIS method.

33.2 Evaluation Indicators

The disassembly of WMEP is a basic approach and important part of the effectively recycling and remanufacturing. Different disassembly sequence leads to different costs and different value of recycling or remanufacturing. The establishment of the evaluation model of WMEP is designed to reduce the economic cost and the secondary pollution of the disassembly process. In this paper, technical, economic, environmental indicators are taken into account to build the indexes system, reflect the nature of the disassembly sequence more comprehensively than previous studies which only considering economic factor.

Technical indicators of the disassembly sequence include security, tool change times, disassembly time and accessibility. Security reflects whether harmful material will be revealed and workers would get hurt. Tool change times show the frequency of tool transformation. Disassembly time can embody disassembly efficiency. Accessibility means the level can be arrived by using disassembly tool, and the size of space for operation.

Main indicators which can influence the economy of disassembly are human consumption costs, tool consumption costs, energy consumption costs and recycling benefits. Different sequences need different resource and energy, so when choosing sequence we should take these economic indicators into account. On one hand, we should make sure the costs lowest, the other hand ensure high benefits.

Environmental indicators are used to judge the level of environmental pollution. We use air pollution level, water pollution level, noise pollution level and solid pollution level to describe the overall pollution levels. This paper use ten-grade to quantify the degree of pollution.

33.3 Evaluation Model

33.3.1 Theoretical Basis

As for the evaluation of disassembly module, scholars studied little about disassembly sequence, but focused more on the evaluation of detachability. There are correlations between products' detachability and disassembly sequence, so the research of disassembly sequence evaluation can learn from the efforts of products' detachability evaluation. Many scholars applied lots of methods to the research of products' detachability evaluation, such as AHP (Chen 2003), fuzzy evaluation method (Zhang et al. 2009), directed network diagram method (Huang 2010), and information entropy evaluation method (Suga et al. 1996). Similar to the detachability evaluation, the disassembly sequence evaluation is also complex and multidimensional. Methods such as AHP are subjective and hard to achieve optimization of evaluation results. Heuristic methods such as genetic algorithms are relatively complex. Based on the characteristics of disassembly sequence evaluation and the requirements that the process should be concise and the results should be optimal, this paper connects entropy method and TOPSIS method to structure the entropy-TOPSIS evaluation model, it can effectively avoid the drawbacks of Experts Grading Method which the weights are given subjectively (Lin 2007; Jiang and Zhang 2006).

TOPSIS is a kind of multi-attribute decision making method. The basic theory is to sort by testing the distance between evaluation objects and the optimal/worst solution. TOPSIS is principle-intuitive and simple in calculation, and requires small sample size (Xu et al. 2011). Entropy method determines the index weight according to the amount of information that delivered from each index, identifies the distribution and variation. Weights from using this method are more objective than traditional approach.

33.3.2 The Evaluation Model

Suppose a kind of WMEP, which the number of feasible disassembly sequence is m. Combined with entropy method and TOPSIS method, indicator information is shown in Table 33.1. Use Si (i =1 to m) to describe sequence 1 to sequence m.

(1) Give specific values for each evaluation indicator list the initial matrix *U, F, T*. Give an example on technical indicators. Get standardized matrix *P* from *U*. Suppose$U_i = [\,U_{i1} \quad U_{i2} \quad U_{i3} \quad U_{i4}\,]^T$

$$U_{ij} = [\,U_1 \quad U_2 \quad \ldots \quad U_m\,] \tag{33.1}$$

$$P_{ij} = [\,P_1 \quad P_2 \quad \ldots \quad P_m\,] \tag{33.2}$$

Table 33.1 Indicators information

Level indicators	Level 2 indicators	S1	S2	Sm
Technical indicators	Security	u11	u21	um1
	Tool change times	u12	u22	um2
	Disassembly time	u13	u23	um3
	Accessibility	u14	u24	um4
Economic indicators	Human consumption costs	f11	f21	fm1
	Tool consumption costs	f12	f22	fm2
	Energy consumption costs	f13	f23	fm3
	Recycling benefits	f14	f24	fm4
Environmental indicators	Air pollution levels	t11	t21	tm1
	Water pollution levels	t12	t22	tm2
	Noise pollution levels	t13	t23	tm3
	Solid pollution levels	t14	t24	tm4

(2) Calculate entropy values, and then transform the entropy values to weight values

$$H_j = -\frac{1}{\ln 4}\sum\nolimits_{i=1}^{m} P_{ij} \times \ln P_{ij}\, W_j = \left(1 - H_j\right) / \sum\nolimits_{j=1}^{4} (1 - H_j) \tag{33.3.}$$

(3) Construct standardized weight matrix R.

$$(R)_{m\times n} = \begin{bmatrix} W_1P_{11} & W_2P_{12} & W_3P_{13} & W_4P_{14} \\ W_1P_{21} & W_2P_{22} & W_3P_{23} & W_4P_{24} \\ \ldots & \ldots & \ldots & \ldots \\ W_1P_{m1} & W_2P_{m2} & W_3P_{m3} & W_4P_{m4} \end{bmatrix} \tag{33.4}$$

(4) Determine the ideal point and negative ideal point.

$$R_j^+ = \begin{cases} \max\limits_i r_{ij}, \textit{forward indicator} \\ \min\limits_i r_{ij}, \textit{ backwardindicator} \end{cases} \tag{33.5}$$

$$R_j^- = \begin{cases} \min\limits_i r_{ij}, \textit{forward indicator} \\ \max\limits_i r_{ij}, \textit{ backwardindicator} \end{cases} \tag{33.6}$$

(5) Calculate the Euclidean distance from true value to ideal point and negative ideal point. Determine the relative proximity.

$$d_i^+ = \sqrt{\sum_{j=1}^{n} \left(r_{ij} - R_j^+\right)^2} \tag{33.7}$$

$$d_i^- = \sqrt{\sum\nolimits_{j=1}^{n} \left(r_{ij} - R_j^-\right)^2} \tag{33.8}$$

$$C_i = \frac{d_i^-}{d_i^+ + d_i^-} \tag{33.9}$$

(6) Make the relative proximity matrix as the initial matrix of first indicators.

$$C_i = [\, c_{i1} \quad c_{i2} \quad c_{i3} \,]^T U' = [\, C_1 \quad C_2 \quad \ldots \quad C_m \,] \tag{33.10}$$

(7) Use above method to calculate the first indicators, and then get final relative proximity.

33.4 Numerical Example

One product has been study for three sequences: sequence 1, sequence 2, and sequence 3. Through the prediction and the actual experts (workers) scoring, data of indicators are shown by s_1, s_2, s_3.

$$s_1 = (8, 3, 34, 6, 450, 80, 120, 75, 4, 7, 6, 5)$$

$$s_2 = (6, 4, 48, 8, 540, 105, 160, 96, 5, 4, 4, 5)$$

$$s_3 = (9, 4, 57, 7, 630, 116, 210, 68, 6, 6, 5, 8)$$

Step 1. Use formula (33.1) and (33.2) to get standardized matrix of technical indicators, then calculate the weight from (33.1). $W = (0.2509, 0.2467, 0.2574, 0.2450)$.
Step 2. By using formula (33.4)–(33.4), we can confirm the ideal point and negative ideal point of technical indicator. Then use formula (33.9)–(33.9) to calculate relative proximity. Using the same method, we can get the relative proximity of economic indicator and environmental indicator. Total results are shown in Table 33.2.
Step 3. According to formula (33.9)–(33.9), we use above method and data of Table 33.2 to get the final relative proximity of three sequences: $c_1 = 0.9173$, $c_2 = 0.7497$, $c_3 = 0.025$. Since $c_1 > c_2 > c_3$, so we choose sequence 1 as the best sequence.

Table 33.2 Relative proximity of level 1

Relative proximity	Technical indicator	Economic indicator	Environmental indicator
s1	0.386	0.7426	0.4918
s2	0.4473	0.5672	0.8143
s3	0.6858	0	0.2528

33.5 Conclusion

This paper analyzed the disassembly process of WMEP, took technical, economic, environmental indicators into account to establish an evaluation index system. The paper connected entropy method and TOPSIS method to structure the entropy-TOPSIS evaluation model. The model can simplify the complexity of the evaluation, and improve the whole efficiency of remanufacturing process.

In this paper, there are still shortcomings, pending further study. For example, indicators in this paper just come from manufacturer, ignored the concern indicators of other stakeholders. In addition, disadvantages of using the method to evaluate disassembly sequence also need to be further analyzed by more empirical research.

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Chapter 34
Research of Method to Achieve a Personnel Quantity Optimization Through Reasonable Number of Production Shift in Manufacturing Enterprises

Ge Wen and Xiao Huang

Abstract How to achieve personnel quantity optimization, especially for the management of production of front-line staff of the manufacturing enterprise is one of the nuclear content of human resources management. This paper put forward that output from the scheme to proceed, through the right equipment, and planned production capacity of the relationship between the measured and reasonable operation of the frequency of production in order to achieve personnel quantity optimization. The AC's case is used to detailed description of the method of measuring production shift.

Keywords Manufacturing management · Job analysis · Production shift · Personnel quantity optimization

34.1 Introduction

Labor force quota is an important foundation work of business management. Preparation of labor fixed number of persons so that enterprise can be reasonable, efficient use of labor and improve labor productivity operation (Dal et al. 2000). On the labor force for the study, there is one important factor often overlooked, namely: reasonable number of production shift (NPS). Regarding the manufacturing industry, in order to improve the utilization ratio of the equipment, and shorten the production cycle of the products, often using a shift system. Therefore, reasonable NPS becomes the important link to personnel quantity optimization.

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34.2 Methodology

34.2.1 Determination of Reasonable Number of Production Shift is an Important Link for Personnel Quantity Optimization

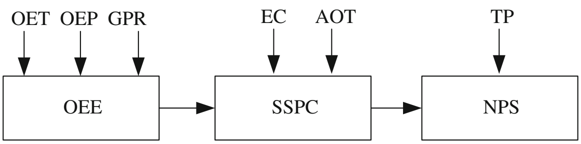
Fixed number of persons is the enterprise in certain production technology condition, in order to ensure their normal production activities, and set all kinds of personnel with the quality requirements and the number of boundaries (An and Yu 2008). Fixed number of persons is based on the period of the plan specified workload and work efficiency. Personnel planning forecasts from the number of personnel equipped with production and non production in manufacturing enterprises. To determine the size of the enterprise, the main business and organization are determined, nonproductive personnel quantity according to a certain proportion of the total number of staffs; and the level of staff in a certain period of time is relatively stable (Yi 2006). On one hand, due to the influence of the market, the product yield is changing; on the other hand, as a result of improvements in technology, equipment efficiency in continuous improvement, equipment hourly production capacity will also change accordingly. Therefore, for manufacturing enterprise, personnel quantity optimization is the key to the production line staff for optimization.

Although shift continuous production can improve the utilization rate of equipment, reduce the production cycle, reduce unit product cost (Gary 2000; Jay and Barry 1999), however, enterprises still need according to the yield and efficiency of the equipment to determine the operation time, thereby determining the NPS. In the manufacturing enterprises found in the survey, 78 % of the enterprises arrangement didn't do quantitative analysis when arrange the production shift. They increase the number of shift because of heavy task, often work overtime and reduced due to yield significantly decreased than in the past. And, in the enterprise that is investigated, only less than 10 % of the enterprises reduced the number of shift, the enterprise of 90 % above is in using determined the number of shift many years ago, or increase the number of shift. Due to the lack of quantitative calculation process, the manager of production department makes it unclear if the current NPS is to achieve optimal.

34.2.2 Steps and Method of Calculation of NPS

Influence of NPS factors are mainly the number of product, overall equipment efficiency (OEE) (Wu and Xu 2007), single-shift production capacity (SSPC). They are shown in Fig. 34.1.

Fig. 34.1 Influence of NPS factors



Calculation NPS steps are as follows.

(1) *Estimation of OEE*: Due to the need for equipment maintenance, all of the equipment can't produce to meet production number theory. At the same time, in the production process inevitably produce bad products, so it can only be used overall equipment efficiency to describe equipment effective capacity.

Method of estimation of overall equipment efficiency is as shown in (34.1). Equations (34.2), (34.3) and (34.4) indicate the calculation of operation efficiency in time (OET), operation efficiency in performance (OEP) and good product rate (GPR).

$$OEE = OET \times OEP \times GRP \tag{34.1}$$

$$OET = \frac{OT}{LT} \times 100\,\% \tag{34.2}$$

$$LT = TWT - PDT \tag{34.3}$$

$$OEP = \frac{SPC \times TP}{OT} \times 100\,\% \tag{34.4}$$

where OEE represent overall equipment efficiency; OET is operation efficiency in time; OEP denotes operation efficiency in performance; GPR is good product rate; OT is operation time of equipment; LT is load time of equipment; TWT denotes total work time of equipment; PDT is planned down time of equipment; SPC is Standard production cycle; and TP presents total production.

(2) *Calculation of SSPC*: SSPC refers to a shift in the year average operation time in the actual production can product quantity (Steven 1996; Gilbert 1997). In calculating the SSPC, in addition to consider the OEE, but also needs to consider the employee statutory working time (Deborah 1994). Equation (34.5) is the Calculation formula of SSPC.

$$SSPC = OEE \times EC \times AOT \tag{34.5}$$

where SSPC denotes single-shift production capacity; OEE is overall equipment efficiency; EC is equipment capacity theory; and AOT is average operation time.

(3) *Calculation of NPS*: NPS depends on SSPC and TP (Ljungberg 1998), it can be calculated as Eq. (34.6).

$$NPS = \frac{TP}{SSPC} \tag{34.6}$$

where TP represents total product of a kind of production and SSPC is single-shift production capacity. Sometimes TP can be replaced with the annual production planning number (Sipper and Bulfin 1997).

When the NPS is determined, the need of staff can be calculate. It will show how this method is use to solve practical problems through a case analysis.

34.3 Application Case

AC Company is a Pieces of Chinese Medicine enterprise, under the jurisdiction of the AC1 and AC2 two production workshop that make different types of production.

AC1 workshop executes four shifts three operation organization modes. Every shift has 157 persons; four shifts are total 628 persons. It plans to produce 550000 pieces 2012 year, OEE is 82 %, EC is 3058.1 pieces/day.

AC2 workshop executes three shifts two operation organization modes. Every shift has 129 persons; three shifts are total 387 persons. It plans to produce 430000 pieces 2012 year, OEE is 82 %, EC is 2070.6 pieces/day.

(1) *Diagnosis of AC Company's current NPS*: Following through on calculation NPS, diagnosis of if AC Company's current NPS existing two workshop is reasonable. According to the regulations by Ministry of labor and social security, years working time is 250 days. Based on the statistics of staff service time, calculate that employee's average annual leave for 11 days in AC1 workshop and annual leave for 10 days in AC2. Calculations are as Table 34.1.

Table 34.1 represents calculations for SSPC and work load rate. The work load rate of AC1 workshop is only 74.77 %. Employees of the legal working time utilization rate is poor, which do not meet the personnel quota principle. In this case, AC Company should consider from two ways to solve the problem, one is to increase the order, so as to make full use of equipment and labor, two is to reduce the persons, saves the manpower cost.

The work load rate of AC2 workshop is 105 %, which exceed 100 %.

(2) *Re arrangement production shift throng estimation of NPS*: According to the above calculation, the SSPC of AC1 workshop is 199800 pieces/year. Its NPS can be calculated as Eq. (34.7).

Table 34.1 Estimations of SSPC for AC1 and AC2 workshop

Workshop	Estimation data				
	OEE (%)	EC (piece)	Years—working time (days)	SSPC (piece/year)	Work load rate (%)
AC1	82	3058.10	239	199800	74.77
AC2	82	2070.60	240	139100	105

$$NPS_{AC1} = \frac{580000\,\text{pieces/year}}{199800\,\text{pieces/year}} = 2.9 \tag{34.7}$$

where NSP_{AC1} is the number of production shift for AC1 workshop.

According to NSP_{AC1}, AC1 workshop can arrange three shifts to produce, and reduce one shift. At this time, Work load rate becomes 96.67 %. After reduced one shift, it can reduce staff 157, personnel quantity is 471.

According to the above calculation, the SSPC of AC2 workshop is 139100 pieces/year. Its NPS can be calculated as Eq. (34.8).

$$NPS_{AC2} = \frac{430000\,\text{pieces/year}}{139100\,\text{pieces/year}} = 3.09 \tag{34.8}$$

where NSP_{AC2} is the number of production shift for AC2 workshop. If AC2 workshop arrangement four shifts, Work load rate becomes 77.25 %. Thus, Work is inadequate. If still according to three shifts for production, Work load rate becomes 103 %. Every staff each standard work day increased work time is 14.40 min and so throughout the year each staff work more 57.60 h. In this case, it can be given to employees for overtime, but does not increase the number of shift. Because adding a shift requires increased by 129 persons, labor costs increase significantly.

34.4 Conclusion

34.4.1 Dynamic Management of Enterprise Personnel Quantity

The reasonable personnel quantity is the important work of enterprise human resources management (Liu and Miao 2003), but also builds harmonious enterprise, implementation manpower cost optimal; effectively avoid the risk of employment base. Because of the goal of enterprise development changed, personnel work ability promoted, technology improved, the continuous upgrading of equipment efficiency, the developing enterprise should do job analysis every 2 to 3 years. Thus enable enterprises to maintain optimal allocation of human resources, reasonable, effective use of labor force.

34.4.2 Through the Estimation of NPS to Maintain Personnel Optimization

According to the equipment capacity and the production task to calculate the NPS is the reasonable arrangement of equipments premise, also is the foundation of effective utilization equipment. When annual production planning developed, Human resources department should forecast NPS, which is the important work archive personnel quantity optimization and labor costs controlling.

34.4.3 Correctly Handle the "Add" and "Decrease" Relationship

When the work load rate is slightly greater than 1, there are two ways without any increase in personnel of the circumstances. One is that for the personnel quantity from the influence of equipment can account for the post between the work adjustments to balance work load rate. Another is that personnel quantity by the influence of equipment can consider additional overtime to compensation, such as AC1 workshop's way in this case.

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Chapter 35
Green Packaging Material: The Application Study and Market Prospect of Molded Pulp Technology

Ting Li and Chang Xiao

Abstract At present, the new green packaging material is exactly a hotspot of current packaging material researching. At the same time, the exploration of green packaging material has been the most active field of packaging science. The application of packaging material will definitely influence function of the wrap page and impression of the packaging design. The pulp molding material, as the typical green packaging material, will draw much attention of researchers, due to its recyclability and remarkable market prospect.

Keywords Green packaging material · Molded pulp · Recyclability · Market prospect

35.1 Introduction

The pulp molding industry has a history for several decades in some developing countries. Now, it has been developed on a large scale in some countries, such as U.S.A, Japan, and Canada and so on. The raw materials of pulp molding products are almost waste paper. The number of its products has grown by 40 % or so per year since 1994. In China, the pulp molding industry also has more than 20 years history, and it had been invested into amount of money and manpower (Zhu 2008). According to incompletely statistics, there are about four to five hundred manufacturers who are engaging in producing and equipment manufacturing of pulp molding, so it has a remarkable market prospect.

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35.2 Methodology

35.2.1 Definition of Molded Pulp

Pulp molding material is made of certain concentration of dehydrated paper pulp by vacuum or pressing method with defined amount of chemical accessories in molding machine with a filter. This material could be recycled (Chen 2008). Because of its special geometry, it has some prime functions, for example, earthquake prevention, impact resistance, antistatic and its protection function to the inner contents due to its elasticity and the similar or better containing quality than foamed plastics in force testing.

35.2.2 Application Areas of Pulp Molding Material

At present, the pulp molding material has been mainly used into two fields: food packaging and industrial packaging (Wei 2007) (Table 35.1).

35.2.3 Age Demand of Pulp Molding Material Application

(1) *Selecting principle of sustainable development*: The recyclable, degradable raw material that has no pollution to human and environment throughout its usage cycle should be selected.
(2) *Selecting packaging design and material appropriately*: In China, there are a lot of over-packaging phenomena now. These packaging pursue modeling and high grade packaging blindly, so the packaging cost is skyrocketed even more expensive than contents wrapped in. It increases the burden on consumers and waste packaging material. According to the statistic of Sanitation Sector, among about 3 million tons rubbish, varied merchandise packages are about

Table 35.1 Food packaging and industrial packaging

Application areas	Material advantage
Medical appliance	Exempt disinfect, no poisonous effect, affordability
Solider article packaging	Good buffering, plasticity, moisture-proof, antistatic, anti shallow radiation
Glass and ceramic fragile	Sanitation, cushioning, low crafting requirement, controllable cost
Planting seeding	It is not necessary for second transplant, time and labor saving
Table ware	Low cost and high safety
Auto industry	Component protection packaging, it has been applied for more than 40 years in some overseas enterprise

830 thousand tons. Among that packaging rubbish, excessive packages occupy 600 thousand tons, which could have been reduced (Xu et al. 2011).

(3) *Showing specific aesthetic and design style through pulp molding material selecting*: (Wang 2006) Getting rid of similarity and exploring creativity are pursued by domestic and foreign enterprises. It is necessary for us to concern with the product design from form and color perspectives, together with pursuing functionality of the packaging (Wang 2006).

35.2.4 The Problems About Packaging Material's Application and Exploration

(1) *The functional quality and protection requirements of the packed commodities for selling.*
(2) *The manufactural technique and usability of the material.*
(3) *The manufactural technique and usability of the material.*
(4) *The consistency of sanitary quality, material and commodities.*
(5) *The requirements of external packing design and printing.*
(6) *The environmental and economic nature of the packaging material* (Huang and Liu 2006).

35.2.5 The Problems About Packaging Material's Application and Exploration

Characteristics of molded pulp, The mechanics and physical characteristics of molded pulp are presented as following (Tables 35.2, 35.3).

Table 35.2 Mechanics characteristics

Mechanical property	Overview
Tensile strength	The maximum pressure beared by per sectional unit area
Bursting strength	The maximum pressure endured by per unit area
Surface strength	The bursting capability of surface and coating film
Tear resistance	The power needed for tearing certain length at a specific cut on pulp molding product
Loading capability	The changes of form under certain pressure
Folding capability	The number of folding times between two 180 degree flat surfaces
Tension resistance	The tension needed for tearing pulp molding flat surface
Hot and humid weight-bearing	The bursting characteristic under certain temperature
Transmitted intensity	The power needed for an article to pierce through a pulp molding flat surface

Table 35.3 Physical characteristics

Physical characteristics	Overview
Whiteness	The clean situation of pulp molding product
Precision	Per cubic centimeter quality
Moisture	Moisture of per unit area
Breathability	Air passing quantity of per minute under vacuum condition on certain unit area
Water resistance	The capability of resisting water during a certain period of time
Thermal insulation	The capability of insulating heat source during a certain period of time

35.2.6 The manufactural Techniques of Pulp Molding Plastic Product (Liu 2012)

Raw material selection. Waste paper, the raw material of pulp molding production, has extensive sources, abundant supplies and is low costing (Liu 2009).

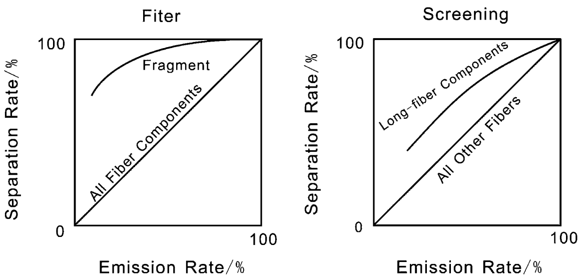
(1) *Recycling of waste paper.*
(2) *Selection of wastepaper*: It is necessary to classify, store and dispose separately the wastepaper depending on its types, properties and purposes. When the wastepaper is selected, it also need to be filtered some impurities, such as metal, sawdust and gravel and so on, in order to get certain purity grade.
(3) *Classifying of wastepaper*: The sources, collecting funnel, quality and wastepaper fiber types are the conditions to classify the recycling wastepaper.

The manufactural process of raw is wastepaper material. Due to the different wastepaper types and different kinds of final products that it makes, the processing procedure and equipments needed are also different. Generally speaking, the processing procedure has the following steps: wastepaper classifying, wastepaper pulp separation, optimization and purification, deinking, concentration, bleaching and pulping (Li 2010).

The general procedure of pulping includes four phases: pulping separation, optimization, purification and concentration (Li 2010).

(1) *Pulping separation*: separating the wastepaper into fiber and fiber suspension, and parted the solid pollutant and some kind of bulky impurities from the wastepaper effectively under the condition of protecting the fiber original tension to the furthest.
(2) *Defibering*: the process of pulping the disintegrated wastepaper into a single fiber.
(3) *Optimization*: removing the impurities and solid pollutants from the recycled pulping as much as possible, and reducing the loss of fiber to the furthest during the pulping process (Yang 2009). The following picture shows the Isolation of the curve (Fig. 35.1).

Fig. 31.1 Optimization



(4) *Purification*: centrifugal purification means to remove, to the furthest, the impurities that degrade the quality of the pulping and abrade the equipment, such as the gravel, metal piece, glass, plastic and other light plastic material impurities.
(5) *Concentration*: after the optimization, it is necessary to dehydrate the pulping and concentrate to certain required density, in order to fulfill the following manufactural procedure requirements—removing pitch, deinking and bleaching.

The molding process of pulp molding production (Dai 2005).

(1) *Vacuum fine pulp molding process*: The vacuum fine pulp molding process means to put a mould with wire net into the attenuate pulp. It formed the vacuum environment in the mould cavity. Under the vacuum environment, a layer of pulp fiber will be sucked onto the surface of the mould wire net, and then we could get the pulp molding product.
(2) *Casting method*: The pulp will flow from the pulp box onto the mould with wire net, and water will flow away through the mesh, however, the fiber will be left on the surface of the mould. When the water runs off, the wet molded pulp could be removed, and it will be extruded and made drying.
(3) *The method of hydroform*: The pulp should be sent into the batcher with stuff pump from pulp vat, after that, pouring drainage molding device. Then, the extrusion head, under the hydraulic pressure action, will stretch into the former to extrude the pulp. [Water will be eliminated from the mesh of the reticular membrane, and the fiber will be molded between the reticular membrane and extrusion head. After the molding, the extrusion head will connect to vacuum to suck out the molding from the mould, then, connect to compressed air to separate the wet molding and the extrusion head.
(4) *Compressing air method*: The fiber pulp will be input to the pulp vat by the stuff pump, and get to the batcher with wire net mould through valve. Then, the vat should be given some hot compressed air and it will press the liquid pulp surface.]Water will be eliminated from the mesh of the mould, and the fiber pulp will be sedimented evenly on the surface of the mould.
(5) *Compact setting wringing*: In order to improve strength of the product to realize the setting and wringing purpose by compacting, one of the effective

Table 35.4 The properties comparison between pulp molding products and EPS foaming plastic products has been listed below

Item	Pulp molding product	EPS foaming plastic product
Environment protection	Recyclable	Big volume, no decomposing, white pollutant
Buffering capacity	Certain buffering	Good buffering
Ratio	Bigger	Smaller
Price	Expensive	Cheap
Output	Product continuously	Mass production
Storage	Small piling	Big piling
Danger	No pyrophorisity	Flammable
Item	Pulp molding product	EPS foaming plastic product
Earthquake prevention	Good	Better
Poisonousness	No poisonousness	Poisonous
Moisture proof	Could absorb some moisture	No moisture proof
Recycling	100 % Recyclable	Not recycling
Resources regeneration	Yes	No
Market prospect	Price restriction	Face elimination
Raw material origin	Regenerated pulp or waste pulp	No fixed source

methods is to use the compact setting equipment to compact the wet pulp between the two membranes (Wang 2009).

(6) *Drying*: The drying of the wet pulp needs to be operated periodically or continuously in chamber dryer channel. When the weather is good, the wet pulp could be dried by using the solar or wind energy. If we put the pulp molding product casually on the drying rack, it will deform easily. So the pulp product could be nested in the dry collating mould and control the drying time and temperature, and the linear dimension changes could be limited.

(7) *Integer*: Hot integer is the most common way for integrating. Hot compressing integer should be operated on hot pressing shaped-machine. Under the same pressure condition, the pressure per unit bearing is smaller, if the size of the work piece is bigger, so the integer effect will be poorer than the others. The water content should be kept between 12 %-15 %, when the hot compressing integer is operated.

35.3 Discussion

The properties comparison between pulp molding products and EPS foaming plastic products has been listed below (Jin 2001) (Table 35.4).

35.4 Conclusion

Through what have been listed, the characteristics, properties and manufacture process of the pulp molding products, we can see that, the molded pulp dose have a remarkable market prospect. It is also in accordance with the green economy, low carbon economy and recycling economy development pattern proposed by the international community.

The pulp molding material, as a kind of packaging material, should adapt to the aesthetic concept on transmitting visual design, and link up the dealers the consumers. The modern packaging should capture the link point of science and art, and the final selection of packaging material should reflect consumers' psychological and visual needs. This could be the developing trend of molded pulp application field.

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Chapter 36
Discussion on Visual Management in Apparel Production Controlling

Yi-ling Zhang

Abstract Visual management as an obvious way of site management, with 5S, lean manufacturing, and other production management, results are obvious. With the development of apparel industry management, VMS also can bring benefits for apparel business. Simply complex requirements, quantitative data, process by diagrams, tables and curves can shorten the time of understanding, so as to reduce the error rate. According to before and after implementing VMS in production site, the research sums up how to apply VMS to control and manage the apparel production site.

Keywords Visual management · Apparel production · Production site

36.1 Introduction

With the development of science and technology, garment enterprise competition became increasingly fierce. And traditional apparel production and management mode are facing new challenges. According to statistics, China's 90 % private enterprises are family enterprises; the majority of them implement family-management (Guo 2009). When the enterprises develop to a certain stage or scale, their family management model and limited management capabilities delayed significantly further than the development of the enterprise, all of phenomenon will put themselves into trouble. How to change apparel production and management mode, to improve comprehensive competitive strength of the garment industry in China in the new century continuously, became a major issue in front of the fashion industry. Among them, production management has an important

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role on high quality garments production, the operating environment and the enterprise image. Some important customers generally to the factory to investigate before deciding to order; and they often pay Attention to the details of site management (Lu 2005). Especially, the good or bad working environment is the most intuitive representation to the level of production management. Customers are often judging the management level and delivery capabilities from working environment. Facing the challenges of production management, companies seek some management methods to pass through.

Some large enterprises has established lean production management mode (Hunan Development of Finance and Leadership Institute 2005), by production in time, total quality management, concurrent engineering, 6S management, visual management and other means to eliminate waste, in order to maximize profits and improve the comprehensive competitive ability of the enterprise itself.

36.2 Visual Management System

Visual Management, as known as the “visible management”, refers to using intuitive method to reveal the station of management and operation, in order to make staffs to see working progress with the eyes clearly and quickly find out proper methods and countermeasures. It depends on visual signals as its basic means, using intuitive and suitable visual perception, color information to organize production activities, so that stuffs can catch the requirements and intentions of managers as clearly as possible (Wan 2003). Therefore, Visual management is characterized by openness and Visual during management (Yu 2003). Features of Visual management are displayed all troubles not only to managers, but also to all employees openly, rather than operating in the black-box. So that VMS make information be communicated fully.

Through VMS, enterprises can gain more adequate, clear, straightforward information; according to the changing information, managers can be simple, rapid to master the moment status of production site. VMS makes the site more obvious, no matter what kinds of people, they can identify the production normal or not easily, through such as revealing cards, signs, cards, lights. Those make the production system more convenient (Xu 2011; Yang 2003). In the apparel industry, human is the most important factors (Wang et al. 2004). So that “quality and delivery time, costs” which be required, coming from of every employees; in other words, habit and attitude of the employees directly affected the core competitiveness of an enterprise. VMS form “forms” to “habits”, its ultimate goal is to make the production process in order, reduce errors, and facilitate management.

36.3 Problem and Countermeasure Analysis

The research object is the clothing enterprise's production site, through interviewing and making questionnaires with the production manager, researching garment production problems in the first production site to search a key to use VMS to control production process. We interview and questionnaire to obtain data by e-mails. The investigation lasted for 4 months, surveyed 43 of garment enterprises, got 189 questionnaires (168 effective questionnaires), and the effective questionnaire of them is 88.9 %. According to anglicizing the results of interviews and questionnaires, we get the following adverse phenomenon of site management (Table 36.1).

For the problems offered above, managers can apply VMS to garment production site to convenience production process and improve efficiency. (1) Flag and identifies brand: managers can use them to distinct production region, devices, goods, and personals, such as in entered region of workshop or specified location using guide flag, in sewing and packaging workshop using lane flag, security flag, ban line flag, and particular device flag. Meanwhile, considered difficulty of production technology, managers should pay attention to key and important processes, and distinguish them from General processes using flags to make checking more easily. (2) Management line and regional line: they make planning of all workshops in ordered, while, apparatus and the other located sites are painted out by management line and regional line. It will prevent workshop device and other goods be placed freely. (3) Management board: In apparel production workshop, the key and most important part is balancing production line (Shan and Zhou 2002). Management board, can be considered as a feedback of production online, can offer production information for workers timely, including their production capacity, the whole production capacity and the bottleneck of production line.

Table 36.1 Problems and analysis

Problems	Apparel production site analysis
Inventory problems	Identity is not clear; different varieties of fabrics and garments are mixed together; unqualified and qualified product are mixed
Delivery problems	Finished and semi-finished products are fixed location, spending a lot of time to look for, affecting progress finally
Efficiency problems (Sun et al. 2004; Bao and Wang 2001)	It is need to take a lot of time to find goods, which are mixed together, resulting in unnecessary loss of time and labor
Security problems	Dangerous device without risk identification; it is difficult to get to get tools easily
Employee motivation problems (Zhang 2003)	Working environment is good or not affect the mood of employees directly; in good work environment, employees have a positive forward-looking attitude to work
Corporate image problems	Customers always consider that production site management reflects the enterprise's management level directly

Management board also can offer early warning before production line occurring exception. So that managers can plan ahead, handling problems timely, ensure the production line in a stable, balanced, efficient station. (4) Text materials, such as job guiding, operation manual: in large production, in order to make the production process standardization, managers should specific each process of producing to format "job guiding" or "operation manual". Text materials not only can guide production, but also can be as "checking standard". (5) Plato or physical "show": to ensure good quality of garment, managers according to analysis the producing problem to make Plato or physical "show". In production station, managers can show the nonconforming up through Plato or physical "show" (Gu and Mccain 2006). Especially in the OEM apparel production enterprises, production must accord to the order completely, in this phenomenon using Plato or physical "show" can make production more accurate. (6) Color: with the difference of production workshop and work nature, the color of work clothes and hats are different (Miao and Yin 2002). Staffs in same workshop use the same species color, different position level staffs use different color, such as sewing workshop staffs with yellow color, and ironing workshop staffs with red color. In addition, apparel production should strict control nonconforming, using VMS to distinguish them in storage management, generally using red or yellow color. Furthermore, different workshop and regional lines have different color. Usually, trunks are with dark color, but the operational areas are with bright color. (7) Route map: Some large enterprises in order to facilitate visitors, learners, set up a simple floor map at the import location. At the same time, visit roadmap also can be used as an escape route one. It is necessary for an emergency evacuation. (8) Regulations publicity and notices: kinds of rules and regulations such as the Personnel Regulation, Safety Regulations, 6S Regulations, Production Specifications, notices and so on, all of them should be posted intensively (Chen 2006).

Research found the following discoveries: (1) Using VMS makes production information clearer. Managers can get more direct channels to gain information. Fast and accurate information can improve managers' ability to analyze and handle problems quickly, so that VMS will significantly shorten the production cycle. Staffs are always arranged to control production site, including the preparation of production schedule, the intensity of production group, and so on. If there is no enough visible information will bring considerable difficulties for production controlling. (2) After implementing, everything in the production site is so clear that managers can reduce organization structure layer and staff number, reducing waste and costs. (3) On the management of material stocks, raw material inventories neither too little, nor too much. Finished products and semi-finished products should be clearly marked on the shelf, using "largest" and "smallest" limited number, below or above the number is a warning. Whether needing to control the production speed or adding reproduction, we can know timely by VMS. Using VMS, managers can meet the production needs in the most economical way, reducing capital occupied in stock, management costs and labor costs, ultimately increasing benefits. (4) Mixing "6S" with VMS will make the workplace better for operating, reduce unnecessary exertion, ensure the production process safe and comfortable, and finally achieve the aim of improving product quality.

36.4 Conclusion

Implementation of visual management improves work efficiency effectively, as well as shortens product cycle, reduces costs and improves the role of product quality. Visual management methods also can be used in the site of garment production to enhance overall competitiveness. Visual management enables the production information visible clearly and more directly, it also helps to improve the production management skills, to analysis information and deal with the problem in time. It will greatly shorten the production cycle. After implementation of visual management, production management level can be reduced obviously, so well as compression, management staffing, cost savings and reduce costs. Managers can easily standardize the site management issues by using visual management methods and following unified principles, especially, combined with the "5S". On one hand, better working environment was given to works by setting the management line and set-line to make the operation area clearly. On the other hand, guarantees were given to improvement of the production safety, accurate and the quality by setting the security mark and Plato physical display.

However, visual management is based on the usage of visual sensory characteristics; and subjective factors exist in organization of production. Therefore, it can be a good way to combine it with the performance system to mobilize the enthusiasm of each employee and to avoid the workers feel it as a burden. Establishment of appropriate rules and regulations is quite needed. Managers also should deal with it from their own tasks, focus on the problems, explain tasks clearly, strictly and making them as habits. It can also take the necessary means and incentives linked to promote the visual management of the production site to carry out.

In short, the outcomes of implementation of visual management in clothing production can't be seen soon. It requires repeated use of continue to improve. In the implementation of the way, we should bravely persevere and keep going, encounter new problems and solve new problems, and so forth in order to make the application of visual management in clothing production site just keep getting better.

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Chapter 37
A Hybrid Sliding Mode Torque Controller for Switched Reluctance Motor

Yong Cheng

Abstract In the paper, a new closed loop system was proposed for torque controlling, which was based on sliding mode control (SMC) in switched reluctant motor (SRM). Analyzing direct instantaneous torque control method and SRM, SMC was introduced in control algorithm with detailed derivations. Relative outgoing phase torque compensation algorithm was proposed. Finally, simulation results indicate this method is validity of eliminating torque ripple in SRM.

Keywords Torque ripple · Direct instantaneous torque control (DITC) · Hybrid sliding mode control (HSMC) · Torque compensation

37.1 Introduction

Switched reluctance motor (SRM) has simple structure and strong robust. It was widely used in different fields. However, doubly salient structure (Miller 1993) has made strong nonlinear and torque ripple, which has effect SRM usage. In terms of torque, many scholars has designed different strategies to minimize torque ripple from different theory (Cheok and Ertugrul 1999; Lin et al. 2005). So scholars proposed modified structure of SRM to reduce torque ripple. Another method was controlling strategy. Current control, switching angle and intelligent control were used in torque ripple reducing. But this method has made progress limitedly. Sliding Mode controller was a useful theory in nonlinear system, which has been made great progress in pass years (Utkin 1977; Zak 1988; Feng et al. 2002; Yu and Man 2002; Shang et al. 2009; Sahoo et al. 2005). In this fields, sliding mode controlling (SMC) had unique advantage. SMC has robust controlling, which need not accurate arithmetic modeling of nonlinear system. In the paper, a hybrid SMC

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(HSMC) was used on torque ripple reducing, which has been proposed to reduce torque ripple at different stages. Controlling system has been set up with torque close loop with direct instantaneous torque control (DITC). By this method, torque was reduced obviously in final simulation.

37.2 Analysis of HSMC

(1) *Controlling strategy on DITC*: DITC was generally acknowledged and effective method of torque control, which took feedback torque as control variety. DITC was used different instantaneous voltage to control output torque in plus torque output area. Here, HSMC was introduced to reduce torque ripple at single phase and commutation region, which composed of SMC and compensate algorithm of commutation region as Fig. 37.1.

In Fig. 37.1, phase (K−1) and phase K meant outgoing phase and incoming phase. In single conductive driving, asymmetry half-bridge circuit was typical circuits, which has three states +1, 0 and −1. In single conductive module, there were single phase and two phases working. In the switching region Z1, phase C and phase B were incoming phase and outgoing phase. In commutation region, incoming phase will go into single phase working stage. Outgoing stage will turn off, which has larger current. In Fig. 37.3, a turn-off strategy was proposed at commutation region. For continuity of SMC, incoming phase will work on independently in single phase. So, it took main role at commutation region, which meant increasing output torque. Outgoing phase will step into turn-off. For reducing torque ripple, outgoing phase took main role at decreasing output torque state, which will corporate with incoming phase. Figure 37.3 showed controlling strategy of outgoing phase. If $T_{err} > \varepsilon$, system need increased output torque, at which outgoing turn on at +1 state. If $T_{err} < \varepsilon$, system need decreased output torque, at which outgoing turn off at −1 state. If $-\varepsilon < T_{err} < \varepsilon$, incoming phase can output enough torque, which meant outgoing deceased slowly at freewheeling state (Fig. 37.2).

(2) *SMC*: Consider the following dynamical system as:

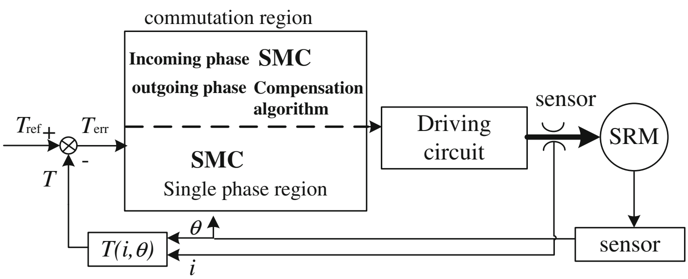

Fig. 37.1 Structure of control scheme

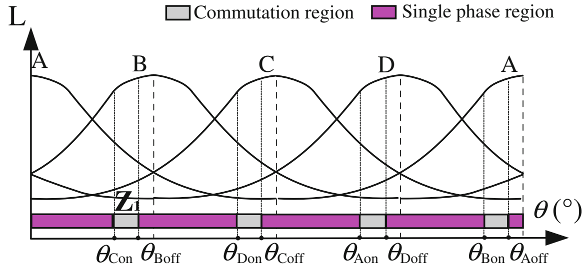

Fig. 37.2 Relation of induction and position angle

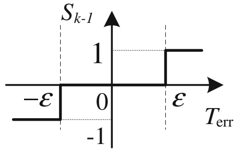

Fig. 37.3 Scheme of torque compensation

$$\begin{cases} \dot{x}_1 = x_2 \\ \dot{x}_2 = f(x) + b(x)u \end{cases} \tag{37.1}$$

where $x = [x_1 \quad x_2]^T$ is the state vector, u is the system control input and $f(\boldsymbol{x})$ and $b(\boldsymbol{x})$ are nonlinear functions. Now, consider a given desired trajectory $x_{1d}(t)$ and the error $e(t) = x_1(t) - x_{1d}(t)$. SM control forces the system, after a reaching phase, to the following sliding line:

$$s(x) = \dot{e} + \gamma e \tag{37.2}$$

where $x_{2d}(t) = \dot{x}_{1d}(t)$ and the sliding constant γ is strictly positive. At steady state the system follows the desired trajectory once $s = 0$. Hence, a suitable control action is to be designed for the system to hit the sliding surface (37.2). We select the Lyapunov function:

$$V = \frac{1}{2}s^2 \tag{37.3}$$

$$\dot{V} = \frac{1}{2}\frac{d}{dt}S^2 < 0$$

According to high dynamic performance and direct instantaneous torque control, switch function was defined as:

$$S = T_{err} = T_{ref} - T \tag{37.4}$$

where T_{err} was error of torque, T_{ref} was reference torque, T is feedback torque. And the control was:

$$u = U_0 \mathrm{sgn}(S) \tag{37.5}$$

All u must meet:

$$\frac{1}{2}\frac{d}{dt}S^2 < 0 \tag{37.6}$$

From equation (37.5), there was :

$$\left[\frac{d}{dt}(T_{ref} - T)\right](T_{ref} - T) < 0 \tag{37.7}$$

Supposing $\frac{d}{dt}T_{ref} = 0$, there was:

$$\frac{d}{dt}T(T_{ref} - T) > 0 \tag{37.8}$$

Torque was function with current and angle, so:

$$\dot{T}(i, \theta) = \frac{\partial T}{\partial i}\frac{\partial i}{\partial t} + \frac{\partial T}{\partial \theta}\frac{\partial \theta}{\partial t} \tag{37.9}$$

With prime voltage function, there was

$$\frac{di}{dt} = \left(\frac{\partial \psi}{\partial i}\right)^{-1}\left(u - iR - \frac{\partial \psi}{\partial \theta}\frac{d\theta}{dt}\right) \tag{37.10}$$

From functions above, there was:

$$u_{\mathrm{eq}} = -\left(\frac{\partial T}{\partial \theta}\frac{d\theta}{dt}\right)\left(\frac{\partial T}{\partial i}\right)^{-1}\left(\frac{\partial \psi}{\partial i}\right) + iR + \frac{\partial \psi}{\partial \theta}\frac{d\theta}{dt} \tag{37.11}$$

Equivalent voltage u_{eq} were influenced by current and derivation between flux, current and angle. In controlling, saturation of voltage was V_{DC}. If u_{eq} was between V_{DC} and $-V_{DC}$, voltage can be adjusted by duty cycle of PWM.

However, equivalent control can easily produce chatter close to boundary. So switching control was selected by error, which was different value within error bands or not to minimize chatter in SMC.

$$u = \begin{cases} V_{DC} \cdot \dfrac{T_{err}}{\phi} & |T_{err}| < \phi \\ \mathrm{sgn}(T_{err}) \cdot V_{DC} & |T_{err}| > \phi \end{cases} \tag{37.12}$$

37.3 Simulation Results

In simulation, Matlab7.6.0 was used as simulating software for SRM 8/6 research, at which turn-on and turn-off angles were set as 6° and 27°. For details of research, waveform were focused on A, B and C phases. The control system was designed

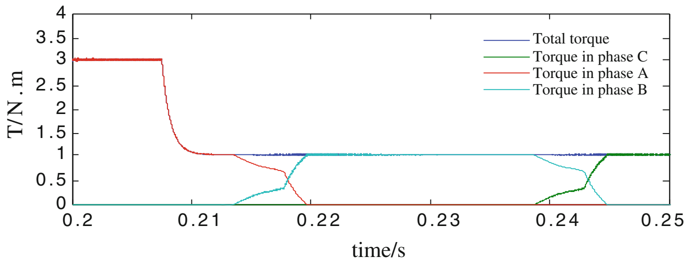

Fig. 37.4 Torque and current *curve* at refered torque changing

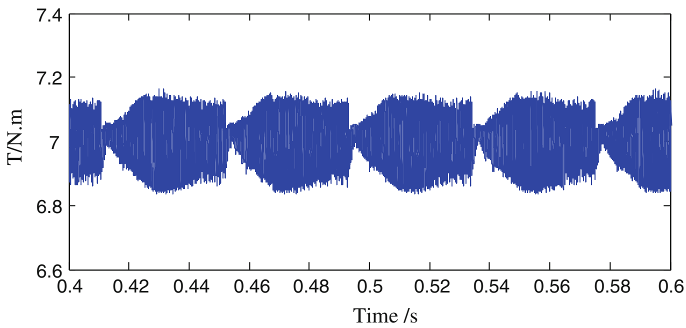

Fig. 37.5 Torque *curve* at steady state under hybrid SMC

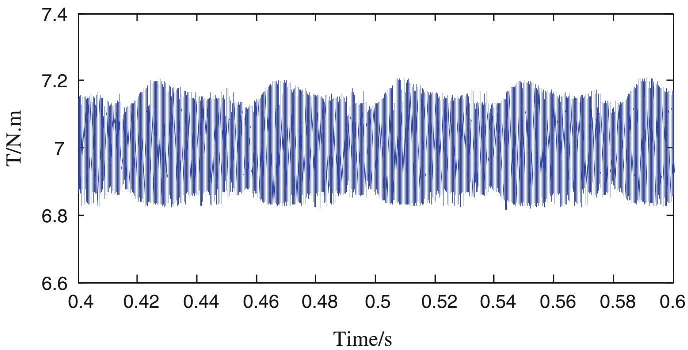

Fig. 37.6 Torque *curve* at steady state under switching type SMC

with DITC structure (Inderka and De Doncker 2002). So sampling torque was derived from table of $T(\theta, i)$, in which angle and current signal were captured from simulating module in MATLAB (Fig. 37.4).

When speed was 600r/m, there was $\varepsilon = \phi = 0.1$ Nm. So output torque has these waveforms as figure below (Figs. 37.5 and 37.6).

From figures above, HSMC can limit torque error between error bands. HSMC has performed better than switching SMC, because HSMC has designed algorithm for output torque, especially in commutation region.

In results, there were two testing parts, which were changing at desired torque changing and details of torque. In first part, there was $\varepsilon = \phi = 0.05$ Nm. and desired torque was changed from 3 to 1 Nm. System has perfect dynamic performance.

37.4 Conclusion

A new torque control base SMC was proposed in the paper. With detailed derivation, HSMC was proposed, which was also proved to be convergent and steady. Simulating results showed HSMC were valid in SRD to reduce torque ripple.

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Chapter 38
Research on Approach of Implementation of New-Type Construction Industrialization in China

Yi-yue Wang and Zhong-fu Li

Abstract This paper states the definition and characteristic of new-type construction industrialization, and analyses the current situation of new-type construction industrialization in China. Then, the paper explores the way of implementation of new-type construction industrialization in China in three aspects, which are construction standardization, construction industrialized production and management integration, and makes specific recommendations on the future direction of the new-type construction industrialization in China.

Keywords New-type construction industrialization · Construction standardization · Construction industrialized production · Management integration

38.1 Introduction

New-type construction industrialization can promote construction development mode from extensive growth to intensive growth. New-type construction industrialization is an inevitable choice to make comprehensive, coordinated and sustainable construction economic development rather than construction economic growth only.

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Construction industrialization is moving towards maturity in the joint efforts of national departments and relative enterprises. Especially the development of new-type construction industrialization is making some breakthrough. Advantages and disadvantages of the new-type construction industrialization have been numerous studied and reported, so this paper only studies the way of implementation and future direction of the new-type construction industrialization in China.

38.2 Definition of New-Type Construction Industrialization

New-type construction industrialization is a new sustainable developed production mode which can achieve construction energy saving, construction environmental protection and the maximize value of full life cycle. New-type construction industrialization makes relevant courses during construction work such as Research, design, materials, accessories production, machine and equipment, construction methods, organization and management as a continuum (Cai et al. 2006; Girmscheid 2005). Only when standardized, industrialized, mechanized, scientific technology is used in construction production, new-type construction industrialization is on track to realization.

38.3 Present Situation of Construction Industrialization in China

(1) *Low level in general and slow development*: From the perspective of construction industrialization, poor quality of materials and Non-structural components is a huge problem. The degree of mechanization of the decoration, plastering and installation courses is less than 10 % in general (Ji 2011). The proportion of new-type building system has declined.
(2) *Desalination of concept of developing construction industrialization and uncertainty technology policy*: There is no clear understanding in whether adhere to construction industrialization or not. Construction industrialization has not been mentioned in a while in the construction industry. Although, some areas still follow the principle of construction industrialization in some respects. The problem whether to continue the development of construction industrialization or not and how to develop construction industrialization is still not solved in the entire construction industry (Guan et al. 2001). So, feasible technology policies of developing construction industrialization combined with the present situation are can not be put forward.
(3) *No supporting economic policy*: The current economic policies in the construction industry are not supporting. So, and construction enterprises can not

obtain the appropriate benefits to adopt the new construction industrialization technology. Sometimes, it costs more and even reduces profits. In this case, construction companies have less enthusiasm to use the advanced technology to realize construction industrialization.

(4) *Lack of necessary coordination*: Vertically, Cooperation and coordination is lack of focus on improving final product quality, improve construction development speed and economic benefits during he research, design, construction and production. Horizontally, there is no coordination among all relevant sectors (Xu and Chen 2009). It is an unsolved problem during a long time. But, to develop construction industrialization, we must organize the interested parties through necessary administrative and economic instruments and being collaborated.

38.4 Approach of Implementation of New-Type Construction Industrialization in China

New-type construction industrialization is a replace performance of the traditional construction which produced mainly by hand. It is a transition from handicraft to a modern mode of production. New-type construction industrialization refers to high-tech and advanced equipment, takes technology as its pioneer, extended to the production of construction parts, products and equipment and use on the basis of construction standardization. Thence, the approach of implementation of new-type construction industrialization mainly should start from Construction standardization, Construction production industrialization and scientific management (Management integration).

38.4.1 Construction Standardization

Construction standardization means using standardized design, components and parts, non-structural components and building system in construction design to make construction simplistic by formatting the standardization and serialization construction products. Construction standardization is a prerequisite for new-type construction industrialization, but also a necessary condition for social coordination during construction production. The standard will be relatively constant for some time once established. So, technical standards of construction standardization should be based on the current, but also need to advance appropriately. Construction standardization should not be overemphasized in the low level of technology. Diversification also needs to consider during the course of standardization. Standardization and diversification can be considered in the same time.

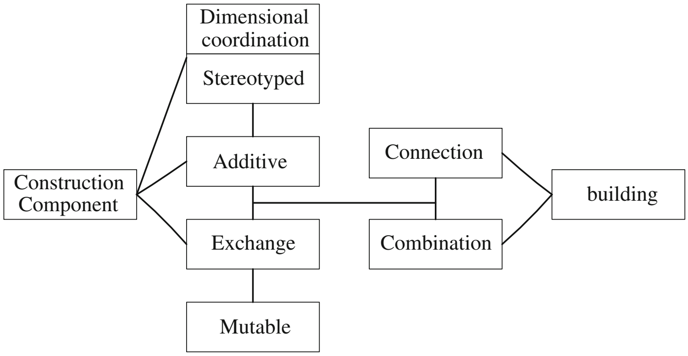

Fig. 38.1 Requirements and functional characteristics of construction standardization

Standardized components of construction can still assemble all forms of construction products.

Figure 38.1 shows the requirements and functional characteristics of achieving construction standardization.

In order to implement construction standardization, the construction structure support system must be solved, which means the study of the standardization of construction structures is necessary. Currently, the most widely applied construction structures (division of structural materials) are brick and concrete structure construction system, reinforced concrete structures, light steel construction system and wood structure construction system (Cai 2005; Yan and Chen 2010). Above all these systems, the brick and concrete structure construction system is the most widely used and familiar. Because it has the features of mature technology, accessible materials and low cost (Schmitz 2004). However, brick and concrete structure construction system is not suitable for the development of construction standardization, such as its characteristic is not conducive to the renovation and to environmental protection, and etc.

38.4.2 Construction Production Industrialization

(1) *Production system of new-type construction industrialization*
Dexterity construction industrialization production system model can be summarized in one sentence: dispersed integrated network production. Dispersed integrated network production is a production mode of realizing construction industrialization. Dispersion refers to the dynamic and unfixed affiliation and geographically separated enterprise members. And network integration refers to organizing the enterprise members by using the information technology and produce as the need of the owners (Chandra et al. 2001).

Fig. 38.2 Technology system structure of construction industrialization

Dispersed integrated network production is an open, multi-platform, cooperated flexible production system which can respond to the owner needs in time by using a variety of different regions, distributed and heterogeneous existing production resources. Dispersed integrated network production puts construction production from designing into producing in a faster speed at a reasonable cost with information technology on the base of fully used existing social resource. And then, dispersed integrated network production opens a way to realize construction industrialization.

(2) *Technology system of construction industrialization*
As construction industry is a broad professional, multi-sector and complexity industry, which is involving designing, materials, equipment and many other subjects (Li 2003). And the development orientation of new-type construction industrialization is based on technological progress. The new-type construction industrialization must have the appropriate technology to support it. Figure 38.2 shows the relationship of every technology of new-type construction industrialization.

38.4.3 Management Integration

Management integration of construction production takes construction products as a management object and divides construction production process into subsystems of different grades or types. Management integration is a management method which integrates the unit management module into a whole management system on the basis of standardization.

Management integration of construction production is a production and operation management method which studies multi-species, multi-volume. Management integration is based on "Contingency Management Theory", integrated use of systems theory, control theory, information theory and the basic principle of "integration" concept of integrated circuit. Management integration takes information of the owners as great importance and fully and accurately predominate the conditions of production and operation. Management integration can improve the whole function of construction industrialization by making a flexible response in time in order to play the role of management. Features of management integration of construction production are: adaptability, short production cycle, high degree of standardization, wide management coverage.

38.5 Development Direction of New-Type Construction Industrialization in China

As the acceleration of the urbanization process and economic development, new-type construction industrialization will be a new growth point to promote China's economic development. The development of construction industrialization should not only learn from advanced technology and mature experience of the development of construction industrialization in the developed countries such as Europe and the United States, but also combine with the specific conditions of construction industrialization in China. Overall, the development of construction industrialization in China should pay attention to the following aspects:

(1) New-type construction industrialization should promote construction structures, including integrated construction system, Steel structure, etc.
(2) New-type construction industrialization should improve the degree of standardization, serialization, stereotyped of construction components and increase the proportion of industrial production of construction parts. New-type construction industrialization should achieve the prefabrication of the structure components including columns, beams, panels, walls, accessories, etc.
(3) New-type construction industrialization should produce and use new green construction materials and achieve the professional and socialized supply of tools including Template system, scaffold.
(4) New-type construction industrialization should realize the rational organization of the construction site, including site assembly, construction, etc. and the application of cleaner construction production technologies in order to promote the "green construction". To develop new-type construction industrialization, impact of construction on environmental should be reduced by creating savings-type site and economical use of resources such as coal oil and gas in the construction process.
(5) To develop new-type construction industrialization, information technology, electronics, automation and other high-technology should be fully introduced in the construction industry. More importantly, digital technology should be promoted in the construction industry.
(6) Integrated management based on the design of the industrial chain, manufacturing and assembly should be valued.

38.6 Conclusion

The traditional cast-in-place technology is used in the production of construction industry in China more often currently. As is analyzed above, a more advanced mode of production is needed in construction industry to change the status quo. New-type construction industrialization has obvious advantages compared with traditional construction mode of production. Therefore, the new-type construction industrialization should be adopted in a wider range of the construction industry in order to further promote the development of the construction industry. This paper discusses about how to develop the new-type construction industrialization from three aspects which is construction standardization, Construction production industrialization and Management integration. New-type construction industrialization will be easier to implement by doing the above three aspects step by step.

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Chapter 39
A Case Study on One-Piece-Flow Production Mode Designing

Dong-sheng Wang and An-zhou Li

Abstract The issues of the case factory's assembly workshop on low circular rate of materials, long production cycle, deficient productivity and their causes are analyzed with Cause-Effect diagram. Some IE methods such as value stream mapping, mathematical modeling, system simulation, signboard management are applied to optimize the means of material supplying of the assembly workshop, to realize one piece flow in the internal cycle between different assembly lines and the external cycle between lines and warehouse.

Keywords One piece flow · Value stream mapping · Signboard management

39.1 Introduction

One-piece-flow production mode is also called JIT production (White 1990). Its basic ideas are to preclude waste and eliminate unqualified products. Specifically, it means that the work-in product between different working processes is zero and that the production is synchronized on established cycle (Johnson and Lawrence 1988). That is supplying materials to every process on required time and quantity. The production scheduling is determined by the ultimate process, and it is executed from the latter process to the former one by order and the materials are received from the former by the latter. The realistic meaning of this mode is, through decreasing the quantity of work-in product between processes, eliminating intermediate warehouses, to implement the principle of "producing according to order" to the producing processes directly, and to optimize the material supplying on different stages, segments and process to achieve the goal of maximum output

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by minimum input (Womack and Jones 1994). The intentions of one piece flow production mode are the followings:

It will actualize the latent quality issue. The mass production mode maintains the balance by large quantity of work-in product (Jiang et al. 2010), which will cause the disconnection between information transmission, feedback and handling. And mass quality issues intend to come into existence when the deficiency appears in the latter process. And the one piece flow mode will actualize the issues because that the deficiency of any stages, segment and process will lead to the suspending of the whole line.

It will synchronize the operations on the production line (He et al. 2006). In the mass production mode, the synchronization on the whole line, even between different processes, is hard to realize because of large quantities of work-in product. And one piece flow mode will realize the synchronization on the basis of operation and by the standard norm of intermediate and finished product (Chu et al. 2005).

It will guarantee the organization's tightness. The enforcement of this mode requires tight organizing means and production management system, which will demand the function and service departments should focus on work field to realize the clear work division on endwise and relation coordination on crosswise (Tugrul and Sedef 2001).

39.2 Description on the Production of the Case Factory's Assembly Workshop

The job of the workshop is to assemble mobile phones. It is dust free, and is closed managed. The production adopts regular flow line on belt conveyers. In the workshop, there are 11 semi-finished assembly lines, 12 finished assembly lines, 11 testing lines, and 1 packaging line. The storage and circulation of materials, semi-finished product and finished product of all the lines' is through one warehouse. The lines are clarified into 3 kinds: L3, L5, and L10. The relationship between them can be described as Fig. 39.1.

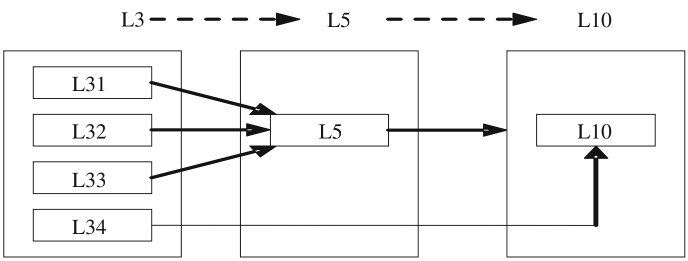

Fig. 39.1 Relationship between lines

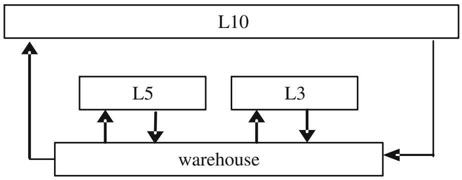

Fig. 39.2 Internal and external cycles

The lines of L3, L5, and L10 make up the internal cycle, and the lines and the warehouse makes up the external cycle. The materials for L3 and L5 are supplied by the warehouse. The semi-finished product is stored and supplied to L10 by the warehouse. The relationship between them is displayed in Fig. 39.2. From Fig. 39.2, we can know that there is each warehousing and delivery for L3 and L5, which causes the issues of the amassing of work-in product, low circular rate, long production cycle and line imbalance.

The improving direction is to optimize the material supplying means by eliminating the warehousing and delivery of L3 and L5; to implement JIT production mode, which means, through signboard and shop-front management, pulling material supplying on fixed amount and unfixed time. The realization of this direction will lead to one piece flow production mode.

39.3 Analysis on the Issues and Causes

In particular, the existing issues are the followings: slow in information feedback, hard to confirm the work spot when deficiency appears, severe waste of hanging, amassing of work-in product, long production cycle, low productivity, and low morale. Value stream mapping analyzing (Hines and Rich 1997) provides a comprehensive resolving way to these issues. From observation and recording on the process of the lines, the value stream mapping can be drawn as Fig. 39.3.

From Fig. 39.3, we can know that the material from the supplier will be stored for 24 h, and the processing time on L3 is 280 s; the semi-product processed by L3 will enter L5 until being stored for 12.4 h, and the processing time on L5 is 720 s; the semi-product processed by L5 will enter L10 until being stored for 18 h, and the processing time on L10 is 480 s. Thus, the production cycle is 54.48 h, the value-added time is 1480 s, and the value-added rate is 1.76 %. Obviously, the rate is rather low.

The main causes of low value-added rate are analyzed with Cause-Effect diagram as Fig. 39.4.

To resolve the issues in Fig. 39.4, the basic ideas are the followings: calculating safe inventory and the lowest work-in product level, implement front-shop and signboard management. Graphics should be in TIFF, 600 dpi (1 bit/sample) for line art (graphics, charts, drawings or tables) and 220 dpi for photos and gray scale images. Please use the drawing tools in Word or Visio to finish your figures and tables.

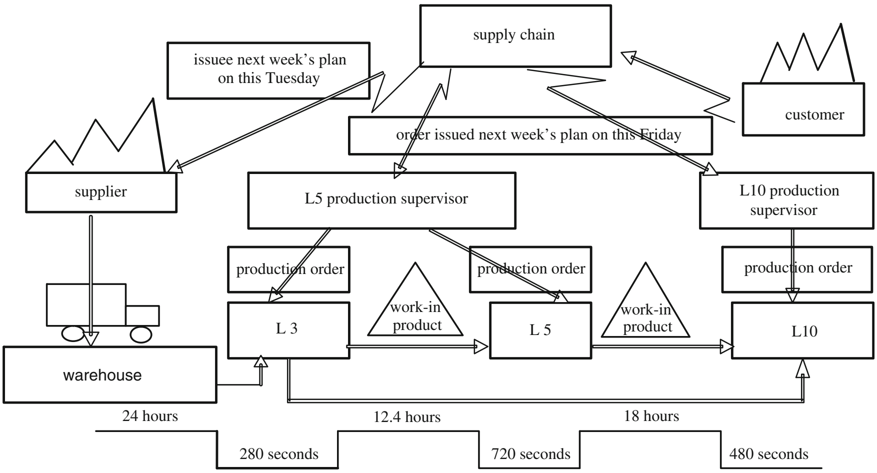

Fig. 39.3 Value stream mapping of the assembly workshop

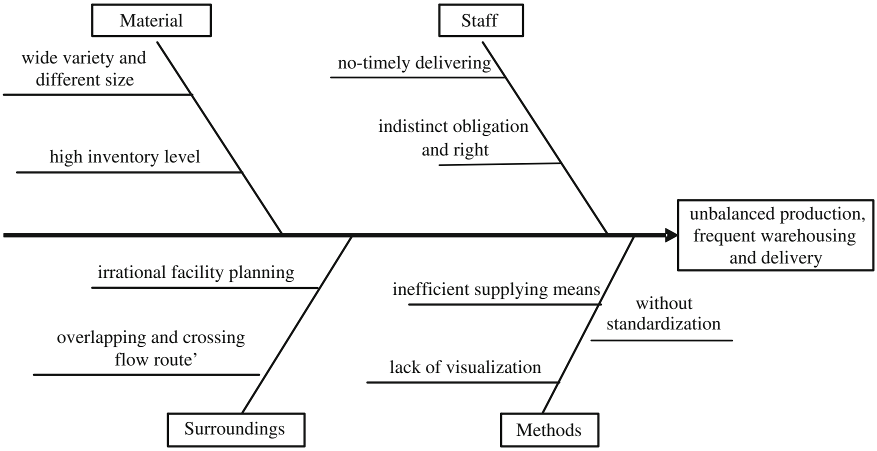

Fig. 39.4 Cause-effect diagram

39.4 The Program Designing of One Piece Flow Production Mode for the Case Factory

39.4.1 Calculate the Safe Inventory Level

Referring Q as the delivering batch, Q_0 as the safe inventory level, UPH_i as the standard of this workshop section, UPH_j as the standard of the former workshop section, t_0 as the time from this section to the former for workers delivering materials, t_1 as the time from the former section to this section for workers delivering materials, and t as the time from the input of materials to reach the level of safe inventory, the following model can be set up (Amen 2000):

$$Q = UPH_j * (t + t_1) \tag{37.1}$$

$$Q - Q_0 = UPH_i * t \tag{37.2}$$

From Eqs. 37.1 and 37.2, Eq. 37.3 can be induced:

$$Q_0 = \left(UPH_j - UPH_i\right) * t + UPH_j * t_1 \tag{37.3}$$

Taking section L5 of the product M as the example, through observing and recording, $UPH_i = 12.94$ pcs/s, $UPH_j = 10.8$ pcs/s, $t = 3600$ s, $t_0 = 300$ s, $t_1 = 720$ s, from Eqs. 37.1 and 37.3, $Q = 400$ pcs, $Q_0 = 80$ pcs. That is, the safe inventory level is 80 pcs, and the maximum level is 400 pcs. When the amount of material on the production line reduces from 400 to 80, the worker will deliver materials from the warehouse or the former process by signboard. And the former section produces parts by required ones items and quantity from signboard.

39.4.2 Diminish the Amount of Work-In Product

Taking the M product as the example, according to its production scheduling and daily output quantity, the safe inventory level of section L3 is 133 pcs, the maximum is 400 pcs; the safe inventory level of section L5 is 80 pcs, the maximum is 400 pcs; the safe inventory level of section L10 is 80 pcs, the maximum is 2000 pcs. And the interval of delivery is 60 min.

With simulation software Flexsim10.0, the result of diminishing the amount of work-in product can be testified as displayed in the screenshot of Fig. 39.5.

From the simulation we can know that there is no amassing of work-in product, the product cycle is shortened notably, and the productivity is improved to fairly high level.

39.4.3 Implement Front-Shop and Signboard Management

Through setting up front-shop for materials and finished product, and making signboards (Vilarinho and Simaria 2002) for each line, the following issues can be resolved: Firstly, the safe inventory level and the maximum level can be calculated for the delivering workers, and when the amount of material on the lines reduces from the maximum to the safe level, the workers will supply for them. Secondly, on the issues listed in Fig. 39.4, the minimum amount of work-in product can be calculated for the application of signboard. Thirdly, on the deficient supplying means between lines and warehouses, through applying front-shop and signboard

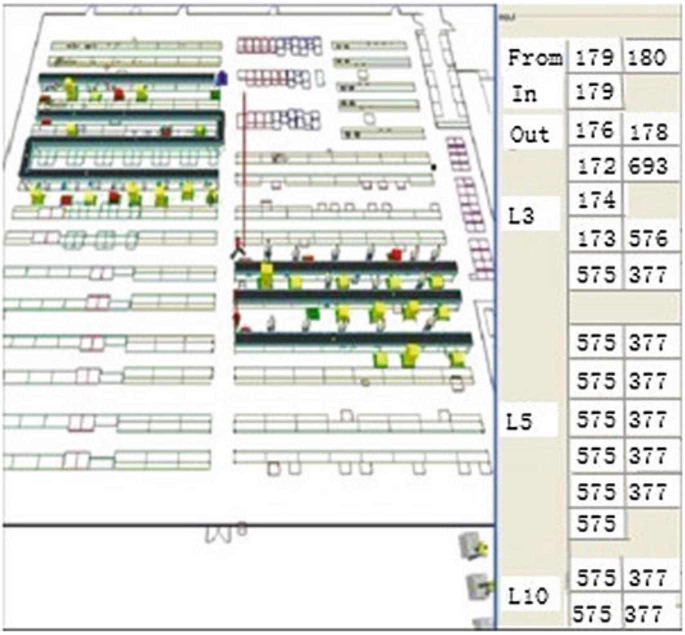

Fig. 39.5 Screenshot of simulation

management and adopting pulling-supply mode on fixed amount and unfixed time, each line can produce abiding by the requirement displayed on signboard.

Specifically, when the lines receive their orders, the warehouse will supply them. The materials will be delivered to the front shop of L3, L5, and L10 for producing. The work stations of each line produce according to signboards between the lines. The semi-products from L3 and L5 will be delivered into the front shop of L10. When the amount of parts on L10 reduces to the safe level, the workers will deliver parts from its front shop by signboards. Thus, the amassing of work-in product will be eliminated, and one piece flow mode will realize.

39.4.4 Analysis on the Improving Effects

The value stream mapping after the improving is displayed as Fig. 39.6.

From Fig. 39.6, we can know that the material from the supplier will be stored for 24 h, and the processing time on L3 is 280 s; the semi-product processed by L3 will enter L5 until being stored for 1.4 h, and the processing time on L5 is 720 s; the semi-product processed by L5 will enter L10 until being stored for 1 h, and the processing time on L10 is 480 s. The production cycle is 26.4 h, the value-added time is 1480 s, and the value-added rate is 1.5 %.

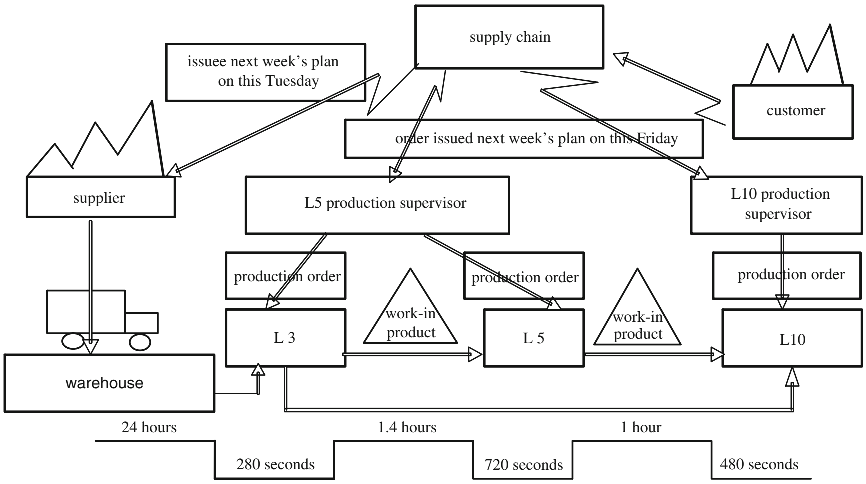

Fig. 39.6 Value stream mapping after improving

Compared with the former indexes, the value-added rate rises by 51.2 % from 0.76 to 1.56 %, and the production cycle reduces by 51.5 % from 54.4 to 26.4 h. The circular rate is promoted, the production cycle is reduced, the productivity is improved, and the morale is enhanced. One piece flow in the internal cycle between different assembly lines and the external cycle between lines and warehouse is realized approximately.

39.5 Conclusion

In conclusion, one-piece-flow production is a mode aimed at reducing production cycle. It will improve the rate of value-added time in the cycle, thus the productivity will rise. With its implementation, it will also supply method to lean production and efficient supply chain management for manufacturing enterprises.

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Chapter 40
An Algorithm of Production Scheduling for Pulling Production Systems with Resource Constraints

Wei Yu, Yu-min Ma and Fei Qiao

Abstract For the production scheduling of bottleneck of pulling production systems with resource constraints, a time-margin-based heuristic algorithm (TMBHA) is proposed to realize the optimization of facility utilization and intermediate inventory based on discrete-event simulation. Compared with manual scheduling and genetic algorithm (GA), the result shows TMBHA is effective in the aspect of efficiency and computation time.

Keywords Bottleneck · Discrete-event simulation · Heuristic algorithm · Resource constraints

40.1 Introduction

The production scheduling of complex production systems is always a hotspot in both academe and engineering (Yuceer and Berber 2005; Chang et al. 2007; Yadav and Xue 2000; Bankston and Harnett 2000). Fierce industrial competition requires customer orders to be not only fulfilled on time, but also manufactured with utmost economic benefit. How to schedule the production of the order-oriented production systems with obvious bottleneck, meeting the requirements of customers and keeping the production costs at a low level, is a tough problem, which universally exists in the manufacturing companies (Yoo et al. 2003; Xiong and Nyberg 2006). If one adds many constraints with regard to the scheduling, the problem becomes a huge one (Paraskevopoulos et al. 2012). This paper deals with the problem of non-preemptive scheduling in a two-stage pulling production system with resource constraints. Generally, it is difficult to keep a proper production of preceding line corresponding to the demand of subsequent line when preceding line is a

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bottleneck (Bao et al. 2012; Drobouchevitch and Strusevich 2001). Therefore, large intermediate inventory becomes necessary to fulfill promptly the production demand of the subsequent line. However, large inventory raises costs. From above statements, simultaneous reduction of inventory and the tardiness is essential to achieve a rational production. For this purpose, in this paper, a time-margin-based heuristic algorithm (TMBHA) for production scheduling is developed to solve the scheduling problem of the preceding line. By being verified in the background of an automobile trim company, the algorithm can meet the business requirements of the scheduling of production line.

40.2 Problem Formulation

The scheduling problem in a two-stage, parallel-unit and multiproduct plant is considered. Each production line consists of multiple machines. Each machine can work on at most one job at a time, and each job cannot be processed on more than one machine. There is no preemption in processing an operation. At the preceding line, jobs use some additional resources which are available in limited quantities at any time, the preceding line is a bottleneck of the pulling production system. Due to the bottleneck, production balance is destroyed between the two lines. To avoid the tardiness caused by such unbalance, many inventories are needed for the subsequent line. Thus, there exists a buffer as the inventory between them and the inventory fulfills promptly the production demand of the subsequent line. According to the customer orders, an equal amount of semi-finished products are taken from buffer to be processed at the subsequent line. In order to avoid the tardiness, the preceding line must produce enough semi-finished products to guarantee there is no supply shortage when the semi-finished products are being processed on the second stage. This is a classical two-stage pulling production system (Pandey and Khokhajaikiat 1996; Hirakawa 1996; Geraghty and Heavey 2004), as shown in Fig. 40.1.

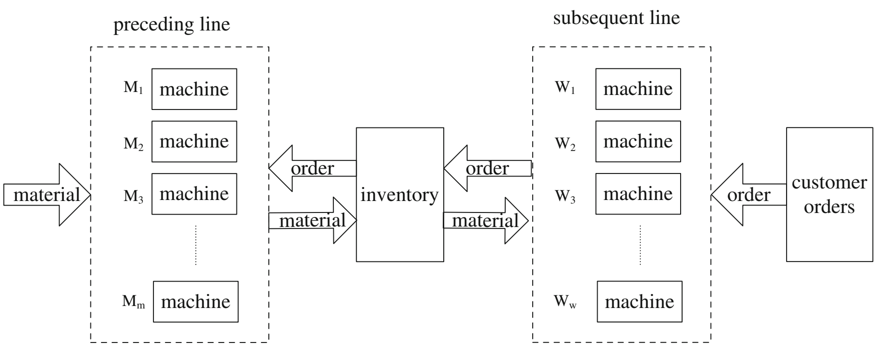


Fig. 40.1 Two-stage pulling production system

The model accounts for many physical constraints, which are likely to occur in practice, such as follows:

(1) Once a job is being processed on the machine, it must be processed continuously until it is completed.
(2) For the characteristics of the operation of preceding line, when a machine finishes a job and begins to do next job, there is a setup time for the machine to prepare, and the time is sequence-dependent.
(3) Each machine has its own working shift and regular maintenance at a specific time. The machine can not work during the time of maintenance and suspension.

We have to schedule the production of the preceding line according to the customer orders. Because of the bottleneck, the machine utilization must be considered. So, we should schedule production with as small setup time as possible. Besides, it costs much to store the inventory, thus, keeping a lower level of inventory reduces the costs. Above all, the objective of the problem is the comprehensive index of facility utilization and inventory.

40.3 Algorithm Design

Assuming that there are m machines in the preceding line and there is no difference between them. Whereas w machines in the subsequent line, each differs from one another. Auxiliary tools are necessary to produce semi-finished products. Different product need different auxiliary tool. A total number of l auxiliary tools are available on the machines of the preceding line. Considering n orders are received during the time span [0, T].

40.3.1 Definition of Parameters

i :	number of order $(i = 1,\ 2...n)$;
j :	number of stages $(j = 1,\ 2)$;
k :	number of machine of preceding line $(k = 1,\ 2...m)$;
p :	number of auxiliary tool $(p = 1,\ 2...l)$;
t :	mark of time $(t \in [0, T])$;
$O_i(P, Q, N, D)$:	O_i-order i, P_i-product required by order i, Q_i-semi-finished product used to produce P_i, N_i-quantity of P_i required by order i, D_i-due date of order i;
T_i :	setup time for the machine of preceding line to process order i;
J_k :	job list of machine k;
I_{it} :	amount of Q_i in the inventory at the time point t;

t_{ij} : processing time of *jth* operation of order i;
T_{ij} : start time of *jth* operation of order i;

40.3.2 Constraints

(1) Because of multiproduct, each auxiliary tool can be used to produce one or more kinds of products. A $n \times l$ matrix Y is used to represent the relationship between the semi-finished products and the auxiliary tools. The element $y_{ip}(i = 1,\ 2\ldots n;\ p = 1,\ 2\ldots l)$ can be valued as "1" or "0" only

$$y_{ip} = \begin{cases} 0 \text{ auxiliary tool } p \text{ is not necessary to produce } Q_i \\ 1 \text{ auxiliary tool } p \text{ is necessary to produce } Q_i \end{cases}$$

(2) Because of the resource constraints, each auxiliary tool has number of only one. And the auxiliary tools cannot be frequently transferred between the machines, for the reason that, the transportation and switch of tools need much time. Thus, we assume that each kind of auxiliary tool can be used on part of the machines, not all the machines. A $l \times m$ matrix V is used to represent the relationship between the auxiliary tools and the machines. The element $v_{pk}(p = 1,\ 2\ldots l;\ k = 1,\ 2\ldots m)$ can obtain the value of "1" or "0" only

$$v_{pk} = \begin{cases} 0 \text{ machine } k \text{ cannot access to auxiliary tool } p \\ 1 \text{ machine } k \text{ can access to auxiliary tool } p \end{cases}$$

40.3.3 Assumption

Each order consists of two operations, the set of first operations consist the jobs of the preceding line, and the set of second operations consist the jobs of the subsequent line. The jobs of the preceding line and subsequent line correspond to each item of the customer orders. And the quantity of products of each job of the preceding line equals to that of the corresponding job of the subsequent line, and also equals to the number of products required by the corresponding order. Thus, there are stable amount of inventory in the buffer during the time span [0, T]. It is expressed by this formula, for each kind of semi-finished product $Q_i,\ I_{io} = I_{iT}(i = 1, 2\ldots n)$.

40.3.4 Algorithm

(1) According to the customer orders, the job lists of the preceding line and subsequent line can be obtained. In the subsequent line, the operation of each order is processed on a determined machine. And the sequence of jobs processed on each machine is determined, the earlier due date, the earlier to be processed. Then, calculate the job list of each machine of the preceding line, it is marked as matrix J. J_k is the job list of machine k, consists of the jobs which will use the auxiliary tools that are accessible on the machine k.

$$J = \begin{bmatrix} O_1 & 0 & \cdots & 0 \\ 0 & O_2 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & O_I \end{bmatrix} YV = [J_1 \quad J_2 \quad \ldots \quad J_k \quad \ldots \quad J_m] \tag{40.1}$$

(2) When machine k finishes a job and begins to select a new job from its job list, calculate the latest time each job $O_q\big(O_q \in J_k$ and $O_q \neq 0\big)$ should be processed, the time point is marked as max $\big(T_{q1}\big)$,

$$\max(T_{q1}) = T_{q2} + I_{qt} * t_{q2} \tag{40.2}$$

where T_{q2} is the start time of order q on the subsequent line, which is calculated by the latest time the job should be processed on the subsequent line, and results in no tardiness,

$$T_{q2} = D_q - N_q * t_{q2} \tag{40.3}$$

If the latest time the job should be processed on the preceding line satisfies the condition:

$$\max(T_{q1}) > D_q \tag{40.4}$$

which indicates the inventory Q_q meets the demand of the subsequent line. That is to say, even if no supplement of Q_q, there is no supply shortage happens. If so, the urgency status of O_q, U_q is valued as "0", it means O_q is not urgent, otherwise, U_q is valued as "1";

(3) Calculate the time margin of each job in the job list of machine k:

$$TM_q = \max(T_{q1}) - t - T_q \tag{40.5}$$

Select the job which has the minimum value of time margin, and mark it as O_A;

(4) Examine whether the processing time TE of other jobs in the job list of machine k is smaller than TM_A:

$$TE_q = t_{q1} * N_q + T_q(q \neq A) \tag{40.6}$$

If $TE_q < TM_A$, the insertable status of O_q, IN_q is valued as "1", which indicates if O_q is processed first, there has no effect on other jobs. If $TE_q \geq TM_A$, IN_q is valued as "0". And then scan the job list thoroughly to find whether there exists the job with $IN_q = 1$, if yes, compare the setup time of machine to prepare of the jobs which has $IN_q = 1$ with that of O_A, select the job which has the minimum value of setup time as the job to be processed. If there is no job which has $IN_q = 1$, select O_A as the job to be processed;

(5) Check whether there still exist jobs in the job list, if all the jobs have been completed, exit, otherwise, return to Step 2 and continue until all the jobs are completed.

40.4 Example

In an automobile trim company, the manufacturing process of the product can be abbreviated to two operations, they are injection molding and welding. First, mold the raw materials into desired shape and store them in the buffer. Then, weld the semi-finished products into finished products and finally deliver them to customers. The operation of molding is completed by molding machine and die. There are six molding machines and 20 pieces of dies. There are five welding production lines in the plant, and each line consists of four welding machines, the four welding machines of a welding line adopt simultaneous processing. The plant adopts the pulling production system. Each machine of the plant works according to its own factory calendar, pauses and maintains at the specific time. Because of the limitation of factory calendar, it is difficult to solve the problem based on the mathematical model only (Wang and Wu 2003; Simth 2003). Thus, we adopt the method of discrete-event simulation on the platform of Tecnomatix Plant Simulation to solve this problem.

40.5 Result Analysis

Take one-week customer orders as the input of the system, adopt TMBHA to solve the scheduling problem, and compare the results of it with that of manual method and genetic algorithm (GA), to evaluate the effectiveness of TMBHA.

40.5.1 Original Data

The basic information includes product information, equipment information and die information. Product information reflects the processing time of the two

Table 40.1 Schedule plan

Product	Quantity	Setup time (min)	Start time	Machine
A_102	96	30	7:30:00	M1
B_101	388	15	09:24:12	M1
A_101	144	10	10:44:37	M1
……	……	……	……	……

operations of different kinds of products. Equipment information records the quantity of the machine in the preceding line and subsequent line. Die information shows the relationship between machines and dies. On the basis of basic information, import the orders into the system as the input. Each order consists of three items: product, due date and quantity.

40.5.2 Data Analysis

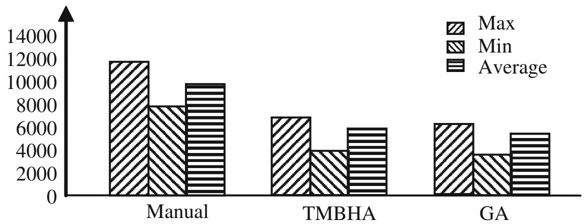
(1) Adopt TMBHA to solve the scheduling problem.

First, convert the orders to the job lists. Each order consists of two operations. The welding operation of each order must be processed on a specific welding machine according to its own process. The sequence of the jobs processed on a welding machine arranges according to the sequence of due date. Adopt TMBHA to calculate the job schedule of each molding machine. The schedule is given in the term of "Product", "Quantity", "Setup time", "Start time" and "Machine", which indicates each molding machine at which time to process which product, as shown in Table 40.1. We calculate the inventories and facility utilization as the two important indices, the results are shown in Figs. 40.2 and 40.3.

(2) Comparison with manual method.

The planners of manufacturing companies usually schedule the production using Excel. The most important principle they should abide by is obtaining as much yield as possible under the premise of no supply shortage. The backward of this method is there is no clear definition of different jobs, which results in great increase of inventory.

Fig. 40.2 Inventory comparison



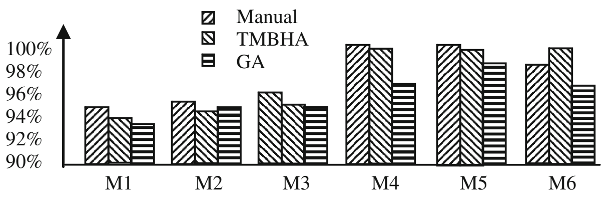


Fig. 40.3 Facility utilization comparison

(3) Comparison with GA.

To further verify the effectiveness of the proposed method, GA is applied to solve the problem. The objective is the minimization of a function comprising the max delay time of the preceding line of orders being considered, as represented by the following mathematical statement: min $\left(\sum_{i=1}^{n}(T_n + t_{i2} * I_{it})\right)$. Assign the population size the same as the number of orders, evolutionary generation is 20, crossover rate is 0.8, and mutational rate is 0.1 (Chan and Hao 2001).

(4) Results.

The result shows that compared with manual method, TMBHA can reduce the inventory obviously, thus to reduce the costs of store. Also TMBHA slightly improves the facility utilization. From these, we can approve the effectiveness of TMBHA.

Compared with GA, TMBHA has advantage in improving the facility utilization, but in the aspect of efficiency and computation time, TMBHA has obvious advantages. For a set of customer orders with 540 items as the input, the computation time of TMBHA is $1'51''$, whereas that of GA is $5'22''$.

40.6 Conclusions

In this research, a time-margin-based heuristic algorithm is introduced for solving scheduling problems of bottleneck in two-stage pulling production systems with resource constraints. It has not only improved the facility utilization but also reduced the inventories. And it is easy to be implemented compared with intelligent algorithms.

This method has been applied to an actual production line, the results indicate that it is useful in industrial environment. It balances production and conforms resources of bottlenecks, and also has theoretical and practical value for improving production efficiency and resource utilization.

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Chapter 41
An Improved Hybrid Intelligent Algorithm for Permutation Flowshop Scheduling Optimization

Jie Chen and Ming-le Ren

Abstract The Max–Min Ant System (MMAS) plunges into local optimum easily when it is applied to solve the Permutation Flow Shop Scheduling Problem (PFSP). An improved hybrid ant colony system is proposed to solve the problem mentioned above. It incorporates the positive & negative feedback rule, mutation rule used in Best-Worst Ant System (BWAS) and Metropolis rule used in Simulated Annealing (SA) into MMAS to update pheromone trails. It uses local search method to improve global search capacity. The experiment on benchmark problems shows that the performance of improved algorithm is much better than MMAS.

Keywords Hybrid ant colony system · Max–min ant system · Optimization · Permutation flowshop scheduling

41.1 Introduction

Permutation flowshop scheduling is a special kind of scheduling situation in which operation sequences through the machines can't be allowed to be changed (Pinedo 2007). It widely exists in manufacturing and service systems, especially suitable to the small batches production with the same production processes and different processing time. It is a typical combinatorial optimization problem, and represents some permutation problems. It is a NP-hard problem with exponential increase of computational complexity when problem scales increased (Tu et al. 2009).

According to the available literatures, the methods to solve Permutation Flowshop Scheduling Problem (PFSP) can be classified into three categories:

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mathematical programming, heuristic algorithms and meta-heuristic algorithms. Among of them, mathematical programming, including branch and bound, linear programming, and etc., only can solve small-scale problems, but they are not suitable for large-scale with high computational complexity. Heuristic algorithms are convenient for large-scale problems including NEH (Nawaz, Ensrore and Ham), CDS (Campbell, Dudek and Smith), Palmer, SPT (Shortest Processing Time) and EDD (Earliest Delivery Date), etc., which have the advantages of simple operation and low computational complexity. However, their global searching capability is weak. Meta-heuristic algorithms, which are widely used in recent years, mainly include Genetic Algorithm (GA), Tabu Search (TS), Simulated Annealing (SA) and Ant Colony System (ACS), etc. Taking advantage of the heuristic information from biological evolution and physical process, these methods have general applicability and lower complexity; however, they cost too much time to solve PFSP.

ACS proposed by M. Dorigo is one of the most popular and widely used meta-heuristics for combinatorial optimization problems (Wang 2006). It was firstly applied to Traveling Salesman Problem (TSP) successfully. Because of its advantages of strong robustness, integration and distributed computational mechanism, it is also widely applied to solve PFSP and proved to be of good performances.

Liu and Liu (2008) defined the heuristic factor as the sum of the processing time of each job and generated the initial solution and pheromone matrix of ACS by NEH, with which the better results can be gotten than NEH. Huang et al. (2010) defined the heuristic factor of each job as the ratio of the sum of subsequent operational time to the sum of total operational time. Rajendran and Ziegler (2004) proposed a total pheromone rule, which makes the job with maximal pheromone trail in position j can be allocated to the neighborhood of j with higher probability to keep the candidate solution to be in the near optimal domain. Liu et al. (2006) presented a converse ant colony system which could avoid being plunged into local optimum. By using simulated annealing algorithm to determine the number of converse ants and divide ants into several parallel group, Yue et al. (2009) proposed a multiple converse ant colony algorithm based on simulated annealing to improve the global searching capacity (Ying and Liao 2004) combined palmer rule into ACS to solve PFSP (Ying and Liao 2004). Zhou (2009) presented a hybrid ant colony algorithm for permutation flow shop scheduling problem, which combined MMAS with BWAS to ensure solutions diversity through pheromone mutation and resetting mechanism (Zhou 2009). Sun et al. (2004) used GA to optimize four parameters of ACS and MMAS to improve path finding performance of ACS.

As a typical NP-Hard problem, PFSP which has the characteristics of large amount of permutations needs long time to get solution, especially when the problem scale increased. When applying ACS to PFSP, searching optimal solution may be easily plunged into local optimum and is difficult to determine the heuristic factor. A lot of researches mentioned above pay much attention to try to solve these problems through algorithm improvement and fusion, and have made some relevant achievements. However, the methods mentioned above still have some shortcomings, such as improper pheromone update rule, premature and ambiguous reset time in BWAS and MMAS, etc.

Among the meta-heuristic algorithms, SA has stronger global search capability and can escape from local optimum to some extent. With its unique positive & negative feedback rules, BWAS has the prominent performance of convergence. Considering the advantages of them, this paper tries to present an improved hybrid ACS, in which the positive & negative feedback and mutation rules of BWAS will be incorporated into MMAS and the SA selection mechanism will be used to replace the resetting rule. The improved hybrid ACS can be able to enhance the solving capacity and quality for PFSP comparing to conventional MMAS.

41.2 Problem Description

PFSP can be defined as follows (Wang 2003): Considering a sequencing problem that has n different jobs to be processed on m machines. Each job has one operation on each machine and all jobs have the same ordering sequence on each machine. At any time, each machine can process at most one job and each job can be processed on at most one machine. Preemption is not allowed. The processing time of each job at each machine is known in advance. The objective is to find a permutation of jobs that makes one or more indexes optimal.

If the objective is to find a permutation of jobs that minimizes the maximum completion time, or makespan. PFSP can be denoted as follows:

Let π be a permutation of jobs, n be the total number of jobs to be scheduled, m be the total number of machines in the flowshop, j_i be the ith job in π, k be the kth machine, $i = 1, \ldots, n$, $k = 1, \ldots, m$, $C(j_i, k)$ be the completion time of job j_i on machine k, $t_{ji,k}$ be the processing time of job j_i on machine k, $C_{\max}(\pi)$ be the maximum completion time, $\prod$ be the solution space. The formulations are as follows:

$$C(j_1, 1) = t_{j_1,1} \tag{41.1}$$

$$C(j_1, k) = C(j_1, k-1) + t_{j_1,k}, k = 2, \ldots, m \tag{41.2}$$

$$C(j_i, 1) = C(j_{i-1}, 1) + t_{j_1,1}, i = 2, \ldots\ldots, n \tag{41.3}$$

$$C(j_i, k) = \max(C(j_{i-1}, k), C(j_i, k-1)) + t_{j_i,k}, \quad i = 2, \ldots, n; k = 2, \ldots, m \tag{41.4}$$

$$C_{\max}(\pi) = C(j_n, m) \tag{41.5}$$

$$\pi^* = \arg\{C_{\max}(\pi) = C(j_n, m)\} \rightarrow \min, \pi \in \Gamma \tag{41.6}$$

Equation (41.6) represents the permutation which has minimum makespan in solution space.

41.3 Hybrid Ant Colony System

41.3.1 General Structure of Hybrid Ant Colony System

In MMAS only the global optimal solution is allowed to update the pheromone trails (Stützle 1998). This can make full use of historical information and speed up convergence rate. Although it can avoid to being plunged into local optimum by set pheromone upper and lower limit, the solution quality obtained by MMAS is not high with many local optimal points in PFSP. Considering the Metropolis rule (Zhu 2011) in SA can improve global search capability and the pheromone trails positive and negative feedback, mutation rules of BWAS (Córdon et al. 2002) can speed up convergence rate, this paper plans to incorporate these rules to the pheromone trails update part of MMAS. With the help of local search, the improved hybrid ant colony system for PFSP is proposed. The general structure of improved algorithm is in Fig. 41.1.

41.3.2 Details Design

- Parameter definition

The main parameters and definitions of improved algorithm can be seen in Table 41.1.

- Initialize

(a) *Generate initial solutions*

According to the characteristics of PFSP, the candidate solutions are coded by natural numbers. When the total number of jobs is n, each candidate solution is one of $n!$ permutations. This paper makes use of NEH (Wang 2006) and Palmer (Tu et al. 2009) rules to generate initial solutions. We can denote them as *solution 1* and *solution 2* respectively. These two rules can be described as follows:

NEH rule:

Step1: Order the n jobs by non-increasing sums of processing time on all machines

Step2: Take the first two jobs and schedule them in order to minimize the partial makespan as if there were only these two jobs

Step3: For $k = 3$ to n do Step4.

Step4: Insert the kth job at the place 1 to $k - 1$, which minimizes the partial makespan among the k possible ones.

Palmer rule:

Step1: Calculate the parameter $S(i)$ of each job

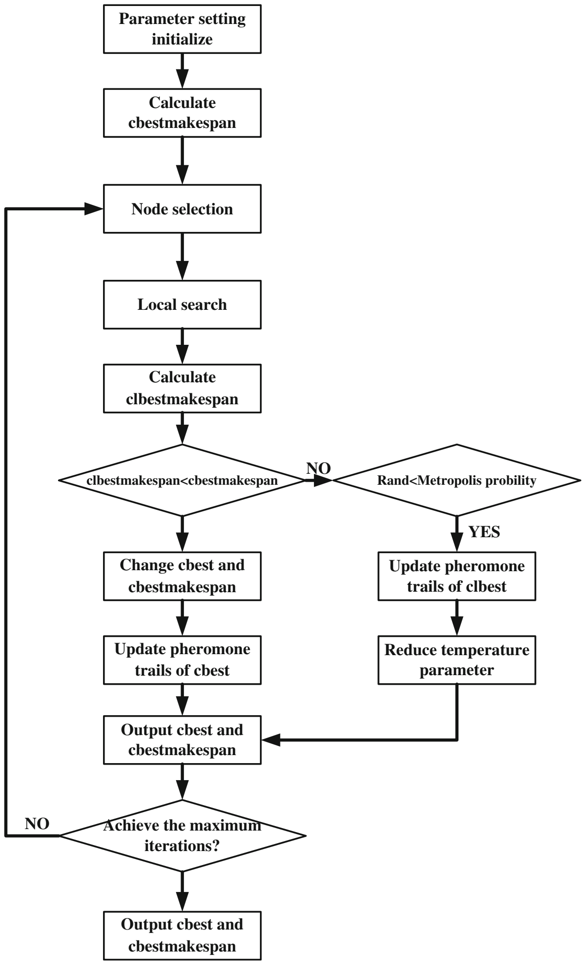

Fig. 41.1 The structure of algorithm

$$S(i) = \sum_{1}^{m} (2j - m - 1)p_{ij}, i = 1, \ldots, n, j = 1, \ldots, m. \quad (41.7)$$

Step2: Order the n jobs by decreasing $S(i)$ and generate the initial permutation.

(b) Initialize pheromone trails

Pheromone trails upper limit $\tau_{\max}$ and lower limit $\tau_{\min}$ will be initialized as first to limit the scope of pheromone trails. First, Calculate the makespan of *solution* 1 and *solution* 2, then denote them as solution 1 makespan and solution 2 makespan. Let the minimum one of them be *cbestmakespan* and its solution be *cbest*. Let the other one and its solution be *cbest*1*makespan* and *cbest*1 respectively. Then, we have

Table 41.1 Parameters and definitions

Parameter	Definition
p_{ij}	The processing time of job i on machine j
τ	$n \times n$ pheromone matrix
$\tau_{\max}$	Pheromone trails upper limit
$\tau_{\min}$	Pheromone trails lower limit
$\tau_{i,j}$	Pheromone trail in row i and column j of τ, $\tau_{i,j} \in [\tau_{\min}, \tau_{\max}]$, $i = 1, \ldots, n$, $j = 1, \ldots, n$
antnumber	The number of ants
p_{miss}	Pheromone trails evaporation rate, $p_{miss} \in [0, 1]$
cbestmakespan	The global optimal makespan
cbest	The global optimal solution
clbestmakespan	The current best makespan
clbest	The current best solution
clworstmakespan	The current worst makespan
clworst	The current worst solution
p_1	The parameter of SA's selection rules
t_0	Temperature parameter
p_0	Select probability in nodes selection
p_m	Pheromone trails mutation probability
generation	The current iteration number
nit	The maximum iteration number
ceta	Mutation parameter
tauthread	Average pheromone trails of global optimal solution
to_visit	The job number that will be chosen at step l for each ant
J	The set of jobs which were already selected before step$l$ for each ant
JN	The set of jobs that are not selected before step$l$ for each ant
$p_{i,l}$	The probability of the ant choosing job i at step$l$,$i \in JN$, $l = 1, \ldots, n$

$$\begin{aligned} \tau_{\max} &= 1000/(p_{miss} * cbestmakespan) \\ \tau_{\min} &= \tau_{\max}/,5 \quad \tau_{i,j} = \tau_{\max}, \quad i = 1, \ldots, n \ j = 1, \ldots, n \end{aligned} \tag{41.8}$$

(c) *Initialize parameter t_0 of SA selection rules*

We use parameter t_0 to control the metropolis selection probability, this formulation is obtained from literature (Tu et al. 2009).

$$t_0 = (cbest1makespan - cbestmakespan)/\ln p_1^{-1} \tag{41.9}$$

- Nodes selection

In order to ensure solutions diversity, this paper combines deterministic selection with random selection. For each ant, a random number named $rand1$ between 0 and 1 is generated at each step. If $rand1 \leq p_0$, the deterministic rule is selected to choose job, otherwise, the random rule is selected. The detail methods are as follows:

(a) *Deterministic selection*

According to this rule, the job *to_visit* that has maximum pheromone trail in step l can be selected. The formulation of *to_visit* is as follows:

$$to\_visit = \begin{cases} \arg\max_{s \in JN}\{\tau_{s,l}\}, & rand1 \le p_0 \\ randomselection, & else \end{cases} \tag{41.10}$$

(b) *Random selection*

Calculate the cumulative probability for each job through $p_{i,l}$ and select the job by roulette, then the final job number is *to_visit*. The formulation of $p_{i,l}$ is as follows:

$$p_{i,l} = \begin{cases} \tau_{i,l} \Big/ \sum \tau_{i,l}, & i \in JN \\ 0, & i \notin JN \end{cases} \tag{41.11}$$

- Local search

When all ants finished nodes selection, *antnumber* candidate solutions will be got. Then three steps are needed to do. First, the whole candidate solutions are needed to swap neighborhood to ensure solutions diversity. Second, partion-NEH local search will be applied to improve quality of solutions. Third, calculate the makespan for all candidate solutions. The minimum of them and its solution are denoted as *clbestmakespan* and *clbest* respectively. The maximum of them and its solution are denoted as *clworstmakespan* and *clworst* respectively. The detail swap and local search are as follows:

(a) *Neighborhood swap*

After some iteration, the candidate solutions may be approached the same. This will make a bad effect on further research. This paper uses neighborhood swap method to ensure solutions diversity. The detail methods are as follows:

Select three positions (u, v, w) randomly in each candidate solution, $u < v < w$. Swap the jobs in position u, v and among of them with ones after position w. If the positions after$w$are not enough, the number of positions for swapping is same with the rest positions after w. The details are as follows. Formulation (41.12) represents the permutation before swapping. Formulation (41.13) represents the permutation after swapping.

$$\pi_{old} = \begin{pmatrix} \pi_1, \pi_2, \ldots, \pi_u, \pi_{u+1}, \ldots, \pi_v, \\ \pi_{v+1}, \ldots, \pi_w, \ldots, \pi_n \end{pmatrix} \tag{41.12}$$

$$\pi_{new} = \begin{pmatrix} \pi_1, \pi_2, \ldots, \pi_{u-1}, \pi_{w+1}, \pi_{w+2}, \ldots, \\ \pi_{w+v-u+1}, \pi_{v+1}, \ldots, \pi_w, \pi_u, \\ \pi_{u+1}, \ldots, \pi_v, \pi_{w+v-u+2}, \ldots, \pi_n \end{pmatrix} \tag{41.13}$$

(b) *Partion-NEH local search*

Partion-NEH local search can improve the quality of solutions obtained by ACS, but the time for searching is too long. In order to keep efficiency of the algorithm, this paper chooses only one candidate solution randomly to execute partion-NEH local search. The detail steps are same with the last three steps of NEH rule.

- Updating of pheromone trails

When all ants finished one iteration and got *clbest* and *clbestmakespan*, the pheromone trails are needed to update according to different situations. When$clbestmakespan \leq cbestmakespan$, conventional pheromone update rule will be selected. Otherwise, the metropolis pheromone update rule will be used.

(a) *Conventional pheromone update rule*

Parameter update: *clbest* and *clbestmakespan* will replace *cbest* and *cbestmakespan* respectively. $\tau_{\max}$ and $\tau_{\min}$ will be reset.

$$cbest = clbest, cbestmakespan = clbestmakespan$$

$$\begin{aligned} \tau_{\max} &= 1000/(p_{miss} * cbestmakespan), \\ \tau_{\min} &= \tau_{\max}/5 \end{aligned} \tag{41.14}$$

Pheromone trails positive feedback: this paper only strengthens the pheromone trails of global optimal solution $\tau_{cbest(i),i}$ to speed up convergence rate, so we have

$$\tau_{cbest(i),i} = \tau_{cbest(i),i} + 1000/cbestmakespan, \quad i = 1 \ldots n, \tau_{cbest(i),i} \in [\tau_{\min}, \tau_{\max}] \tag{41.15}$$

Pheromone trails negative feedback: this paper only weakens the pheromone trails of worst solution in this iteration.

$$\begin{aligned} &\tau_{clworst(i),i} = (1 - p_{miss}) * \tau_{clworst(i),i}, \quad i = 1 \ldots n, \\ &clworst(i) \neq cbest(i), \quad \tau_{clworst(i),i} \in [\tau_{\min}, \tau_{\max}] \end{aligned} \tag{41.16}$$

Pheromone trails mutation: the pheromone trails are mutated according to BWAS to ensure solutions diversity. Generate a random number named *rand*1 between 0 and 1 for each pheromone trails. If $rand1 \leq P_m$, the mutation is executed. The detail mutation formulations are as follows.

$$\tau_{i,j} = \begin{cases} \tau_{i,j} + generation * ceta * tauthread/nit, & rand \leq 0.5 \\ \tau_{i,j} - generation * ceta * tauthread/nit, & rand > 0.5 \end{cases} \tag{41.17}$$

$$\begin{aligned} & tauthread = \sum_{i=1}^{n} \tau_{cbest(i),i}/n, \quad i = 1 \ldots n, \quad j = 1 \ldots n, \\ & \tau_{i,j} \in [\tau_{\min}, \quad \tau_{\max}] \end{aligned} \tag{41.18}$$

For early search stage, the performance of mutation is not obvious. This can speed up convergence rate. When the search is in late stage, the proportion of mutation is increased. This can ensure solutions diversity and avoid to being plunged into local optimum. Unlike BWAS, the improved algorithm replaces the reset rule with SA selection mechanism. Therefore, the mutation operator of improved algorithm doesn't include reset parameter *generationr*.

(b) *Metropolis pheromone update rule*

BWAS only strengthens the pheromone trails of global optimal solution. Although incorporated mutation and reset rules, it's still easily plunged into local optimum. The reset time is often set by maximum iteration number or the similarity between the current best solution and worst solution, but in practice, the performance is usually not good. SA has global search capability. It accepts some inferior solutions in early stage which can ensure solutions diversity. In late stage it only accepts good solutions to ensure convergence rate. According to these characteristics, this paper updates the pheromone trails of *clbest* by Metropolis rule of SA rather than the pheromone reset mechanism. This operation can keep some pheromone trails of good solution and avoid to being plunged into local optimum. The detail operations are as follows:

Generate a random number named *rand* between 0 and 1. Let $e^\wedge((cbstmakespan - clbstmakespan)/t_0)$ be selection probability p_s. If $rand \leq p_s$, three steps are needed to execute. First, strengthen the pheromone trails of current best solution. Second, weaken the pheromone trails of current worst solution. Third, update the parameter $\tau_{\max}, \tau_{\min}$ and t_0. The methods are similar to the formers. The detail formulations are as follows.

$$\begin{aligned} \tau_{\max} &= 1000/(p_{miss} * clbestmakespan), \\ \tau_{\min} &= \tau_{\max}/5, t_0 = 0.95 * t_0 \end{aligned} \tag{41.19}$$

$$\tau_{clbest(i),i} = \tau_{clbest(i),i} + 1000/clbestmakespan, \quad i = 1 \ldots n, \tau_{clbest(i),i} \in [\tau_{\min}, \tau_{\max}] \tag{41.20}$$

$$\begin{aligned} \tau_{clworst(i),i} &= (1 - p_{miss}) * \tau_{clworst(i),i}, \quad i = 1 \ldots n, \\ clworst(i) &\neq clbest(i), \tau_{clworst(i),i} \in [\tau_{\min}, \tau_{\max}] \end{aligned} \tag{41.21}$$

- Output the results

Outputs are *cbest* and *cbestmakespan* of each generation. When *generation* is equal to the maximum iteration number *nit*, the algorithm is stopped.

41.4 Discussion

41.4.1 Introduction to the Experiment

In order to verify the validity of the improved algorithm, the algorithm is coded in matlab and run on 2G memory, Intel 2.53 GHz PC to make an experiment. The test set is a benchmark problem called Rec. Such problems include 21 subproblems which can be divided into seven scales. The scale of each subproblem (job number/machine number) varies from 20/5 to 75/20 and the optimal makespan or upper limit is known in advance. The detail data is in literature (Wang 2003). The experiment is running five times for each subproblem and the best makespan of the five results is denoted as the result of the subproblem. The detail parameters are set as follows: $antnumber = 10$, $nit = 2500$, $p_1 = 0.1$, $p_m = 0.25$, $ceta = 4$, $p_{miss} = 0.25$, $p_0 = 0.7$. Especially, with the large scale of subproblems Rec37 to Rec41, *nit* is equal to 500 and other parameters don't change.

41.4.2 Introduction to the Experiment Results Analysis

Compare experimental results with the results of MMAS and ACS in literature (Zhou 2009). This paper takes the Relative Percentage Deviation (RPD) as the evaluation indicator. $RPD = 100 * (A - B)/B$. A represents for experimental results of such subproblem, B represents for the optimal makespan or upper limit of such subproblem which is known in advance. The detail results of comparison are in Table 41.2. AM is denoted as the results of the improved algorithm and the data in bold is inferior than MMAS.

Four conclusions can be got from the comparison. First, the average RPD of the improved algorithm is less than MMAS and ACS. Second, the results of 21 subproblems are all better than ACS. Third, only two results, Rec05 and Rec07, are inferior to MMAS. Last, the improved algorithm obtains the optimal solution in four subproblems—Rec01, Rec03, Rec11 and Rec35. The improved algorithm has ability to increase search space as the generation increased and we can make the example of subproblem Rec15 to illustrate it. The detail performance can be seen in Fig. 41.2.

Table 41.2 Comparison of REC problem

Problem	AM		MMAS [10]		ACS [10]		Optimal makespan [12]
	Makespan	PRD	Makespan	PRD	Makespan	PRD	
	1247	0	1249	0.16	1271	1.92	
Rec03	1109	0	1110	0.09	1111	0.18	1109
Rec05	**1245**	0.24	1243	0.08	1266	1.93	1242
Rec07	1572	0.38	1584	1.15	1697	8.37	1566
Rec09	1538	0.07	1557	1.30	1611	4.81	1537
Rec11	1431	0.00	1436	0.35	1452	1.47	1431
Rec13	1943	0.67	1957	1.40	1969	2.02	1930
Rec15	1955	0.26	1960	0.51	1993	2.21	1950
Rec17	1919	0.89	1935	1.74	2004	5.36	1902
Rec19	2125	1.53	2127	1.62	2163	3.34	2093
Rec21	2046	1.44	2050	1.64	2054	1.83	2017
Rec23	**2039**	1.39	2027	0.80	2091	3.98	2011
Rec25	2562	1.95	2567	2.15	2622	4.34	2513
Rec27	2413	1.69	2421	2.02	2461	3.71	2373
Rec29	2334	2.06	2354	2.93	2378	3.98	2287
Rec31	3138	3.05	3140	3.12	3174	4.24	3045
Rec33	3142	0.90	3151	1.19	3163	1.57	3114
Rec35	3277	0.00	3277	0.00	3355	2.38	3277
Rec37	5150	4.02	5182	4.67	5366	8.38	4951
Rec39	5247	3.15	5249	3.18	5429	6.72	5087
Rec41	5205	4.94	5226	5.36	5317	7.20	4960
Average	1.36		1.69		3.81		

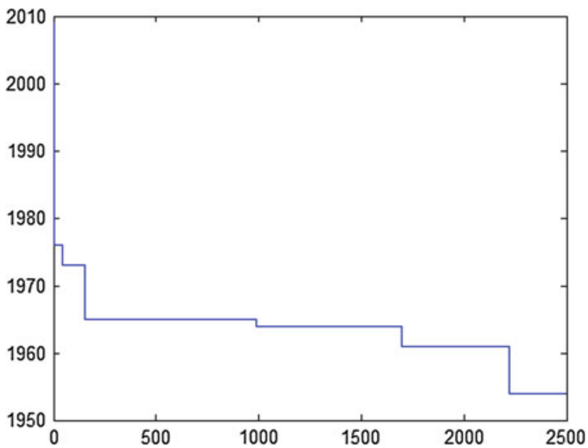

Fig. 41.2 The convergent performance of problem Rec1

41.5 Conclusion

This paper incorporates positive and negative feedback, mutation rules suggested by BWAS and Metropolis rule suggested by SA into MMAS and forms an improved hybrid ant colony system. Taking use of the improved algorithm, the probability of being plunged into local optimum is decreased obviously when used to solving the PFSP. The experimental results show that improved algorithm is better than MMAS in the quality of solutions. However, there still exist some shortcomings for the large scale problem. The further research can focus on the following problems:

(a) *Achieve a balance between solution quality and time efficiency.* The improved algorithm costs longer time in large scale problems. The future research should seek a method to shorten search time without change solution quality.
(b) *Consider the heuristic information.* Let the dominance of good solutions be obvious and offspring can inherit the dominance.
(c) *Improve the robustness of algorithm.* Improved algorithm exist some fluctuations in large scale problem. How to eliminate the fluctuations of the improved algorithm is needed to consider.
(d) *Integrate ACS with other algorithms.* The performance of improved algorithm shows that ACS can be easily to integrate with other algorithms. Making full fusion with other algorithms and improving comprehensive abilities of ACS are further study in the future.

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Chapter 42
Application of Niche Cellular Genetic Algorithm in Vehicle Routing Problem with Time Windows

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Abstract The logistics industry is developing rapidly; however, it is still in limited quantities and with many dynamic changes, and logistic distribution route optimization is becoming increasingly important. Since the design of a quick and effective optimization method should be given the priority in solving this problem. For this reason, the paper presents a new niche cellular genetic algorithm based on canonical cellular genetic algorithm by introducing niche technology, which can maintain the population diversity very well. This algorithm is then applied to the vehicle routing problem with time-window. And an order-reversing crossover operator is designed for solving this problem. The results show that, compared with the canonical cellular genetic algorithms, niche genetic algorithms and simple genetic algorithm, the new algorithm avoids pre-mature more effectively, and the results gained is of higher accuracy. It is of great efficiency in solving the vehicle routing problem with time-window.

Keywords Route optimization · Cellular topological structure · Genetic algorithm · Niche technology

42.1 Introduction

With the economic and social development in recent years, logistics industry is developing rapidly, and is becoming a significant field in the economic development of China. The modern logistics cover various areas such as, production-

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manufacturing, consumption recycling, product distribution, etc. A lot of companies are stressing on logistics to decrease the cost and enhance the market competition. The vehicle routing problem, (VRP), as a crucial part during the logistics distribution optimization, is attracting more and more attention from the researchers.

The vehicle routing problem with time windows (VRPTW) is a kind of VRP with constraints that the vehicle should reach the destination in a limited time, or the customer will not be satisfied. Besides the driving time, the waiting time for arriving the service point ahead of time and the penalty for being later should be taken into consideration in solving this problem. Therefore, this problem is far more complex than any other common VRP, and it is a NP hard problem (Savelsbergh 1985). Since VRPTW problem is closely related to practical applications, a lot of in-depth studies have been done on it. The existing methods for solving VRPTW problems are: taboo search algorithm (Ho and Haugland 2004; Duhamel et al. 1997) simulated annealing algorithm (Yang et al. 2006), particle swarm algorithm (Li et al. 2004), immune algorithm (Li 2006), ant colony algorithm (Yue et al. 2006; Liu and Li 2006; Zhang et al. 2007), and some improved genetic algorithms (Zhang et al. 2006; Zhang and Wu 2007; Wang et al. 2009), and with these methods some preferable results have been gained to solve VRPTW problems.

Cellular genetic algorithm (cGAs) (Alba and Bernabé 2008) is a new evolutionary algorithm gained by collecting cellular automata with genetic algorithm. As for this cGAs, the population is distributed in a special topological structure, generally in a two dimension circle structure and the genetic operation of each individual in the population is done with the specified neighbors. This structure ensures the algorithm a fine-grained paiallel function (Bernabé and Alba 2006), and the algorithm is of good global and local searching ability. Therefore, based on the canonical genetic algorithm and introducing the niche technology, a niche cellular genetic algorithm (NCGA) is proposed in this paper to further improve the population diversity and avoid local convergence. NCGA is applied to the VRPTW problem, and a modified crossover operator is introduced to obtain a better result for this problem.

42.2 Logistics Distribution Route Optimization Model

Supposing the company has M delivery centers in, and there are N customers, then the main task of VRP is to deliver the goods from the M delivery centers to the N customers, meeting the customers' requirement and also minimizing the cost of delivery. The delivery work for each customer is distributed to the delivery center which is the closest to the customer's site, and then each delivery center will be only in charge of the delivery work in a certain area, thus the multi-delivery center is changed into single-delivery center. The single-delivery center mathematical model is as follows.

A delivery center has m vehicles with the capacity of Gt, and the goods are delivered to n customer points, i.e. this problem is to arrange the n points, satisfying the delivery demand and minimizing the total cost for the delivery.

42.2.1 Basic Assumptions

(1) The customers' sites and their demand amount for each delivery center are defined;
(2) The distances between each customer's site and the delivery centers and the distances between customers' delivery sites are given;
(3) Each customer must be served once by only one vehicle;
(4) Only unloading is accepted,while loading is never permitted when arriving at each customer site;
(5) The route of each vehicle must start and end at the delivery center;
(6) The vehicles in the delivery center are of the same kind, and the rated load of the vehicles is defined;
(7) The average speed of the vehicles is defined.

42.2.2 Constraints

(1) No vehicle should carry load exceeding the rated load;
(2) Time windows constraints; the time windows are divided into hard time windows and soft time windows. The tasks of each service center i should be finished in the limited time range $[ST_i, ET_i]$, where ST_i represents the earliest time when the task can be started, while ET_i is the latest time when the task should be finished. If the vehicle arrives at the customer's site before ST_i, it will have to wait; if the arrival of the vehicle is after ET_i, the task will be delayed. T_i is the time when the vehicle arrives at the destination. Is it is the hard time windows, T_i must satisfy the constraint $ST_i \leq T_i \leq ET_i$; if it is the soft time windows, there will be penalty if it is earlier than ST_i or latter than ET_i.
(3) The delivery route is unidirectional; each vehicle must start at the delivery center, and service the customers along with the route. Each customer must be served by the given vehicle and no vehicles are allowed to get back to the former customer after the service. It is in the unidirectional route and each vehicle must end at the delivery center.

42.2.3 Mathematical Model

$$\min D = \sum_{i=0}^{n} \sum_{j=0}^{n} \sum_{k=1}^{m} P_{ij} x_{ijk} + a \sum_{i=1}^{n} \max(ST_i - T_i) \ldots + b \sum_{i=1}^{n} \max(T_i - ET_i) \qquad (42.1)$$

S.T.:

$$y_{ik} = \begin{cases} 1, & \textit{when vehicle k serves the customer i} \\ 0, & \textit{if not} \end{cases} \quad (42.2)$$

$$x_{ijk} = \begin{cases} 1, & \textit{when vehicle k goes from customer i to customer j} \\ 0, & \textit{if not} \end{cases} \quad (42.3)$$

$$\sum_{i=1}^{n} q_i y_{ik} \le G; \; k = 1, 2, 3, \ldots, m \quad (42.4)$$

$$\sum_{k=1}^{m} y_{0k} = m \quad (42.5)$$

$$\sum_{k=1}^{m} y_{ik} = 1; \quad i = 1, 2, 3, \ldots, n \quad (42.6)$$

$$\sum_{i=1}^{n} x_{i0k} = 1; \quad k = 1, 2, 3, \ldots, m \quad (42.7)$$

$$\sum_{i=0}^{n} x_{ijk} = y_{jk}; \quad j = 1, 2, 3, \ldots, n \quad (42.8)$$

$$\sum_{j=0}^{n} x_{ijk} = y_{ik}; \quad i = 1, 2, 3, \ldots, n; \quad k = 1, 2, 3, \ldots m \quad (42.9)$$

where, D represents the total distance that the vehicle has driven; i is the customer's number; j is also the number of the customer; n is the total number of the customers; k means the kth ($k = 1, 2, \ldots, m$) vehicle; P_{ij} is the cost of the delivery from customer i to customer j; q_i represents the goods demand of customer i; G is the rated load of the vehicles; T_i is the time when vehicle arrives at the customer i; a and b are two parameters.

The above mentioned formula (42.1) shows the delivery cost, including the delivery cost of the vehicles and the penalty cost for violating the time windows; formula (42.2) (42.3) present the decision variables; formula (42.4) means that each vehicle should not exceed the rated load; while in formula (42.5), it is clear that each vehicle starts and ends at the delivery center; formula (42.6) indicates that each customer must be serviced by only one vehicle; formula (42.7) shows that each vehicle must get back to the delivery center after the service; formula (42.8)(42.9) reveal the relations between the two decision variables.

42.3 Niche Cellular Genetic Algorithm

So as to perform optimizing calculation on the above mentioned VRPTW optimization model, a new niche cellular genetic algorithm (NCGA) is proposed, which introduces niche technology on the basis of the canonical cellular genetic algorithm. NCGA performs well in maintaining the population diversity and avoiding "premature".

42.3.1 Cellular Genetic Algorithm

Cellular Genetic Algorithm (Alba and Bernabé 2008) is the combination of cellular automata and genetic algorithm, the individuals in which is distributed in a certain kind of topological structure, and in general it adopts two-dimensional structure. As is shown in Fig. 42.1, all the individuals are with the same numbers of neighbors, and the genetic operation of the individuals can only be done among the specified neighbors. In this way, the selection pressure of the algorithm is decreased to some extent, which indicates the cellular genetic algorithm's effectiveness in solving complicated problems.

Analysis of the procedures in Fig. 42.2:

(1) distribute the population in a two-dimensional annular topological structure;
(2) select one cellular from the neighbor to be the parent;
(3) crossover the selected cellular with the central cellular, and then mutation is done;
(4) new individuals are generated;
(5) replace the central cellular with the new generated individual if it is superior than the former one; if not, no replacement is done;
(6) if generation < MAXGEN, find out the optimal solutions; if not go back to step(2);
(7) output the present optimal solution.

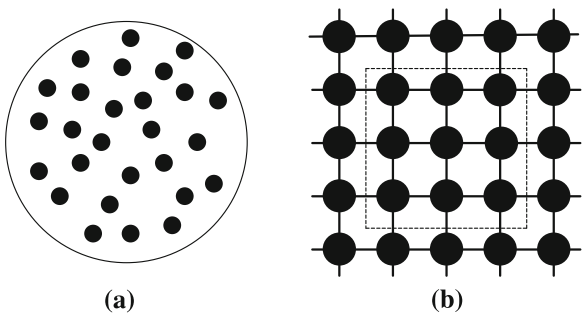

Fig. 42.1 Population distribution. **a** The population distribution of the common genetic algorithm, **b** the population distribution of cellular genetic algorithm

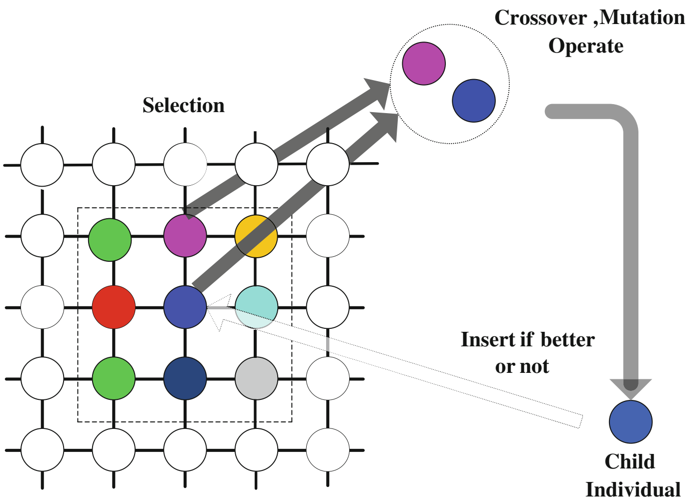

Fig. 42.2 Canonical cellular genetic algorithm

42.3.2 Niche Technology

This paper adopts niche technology based on crowding mechanism. A crowding factor CF is preset, and $1/CF$ individuals are selected randomly from the population to form the crowding individuals. According to the generated individuals' similarity to the crowding individuals, the similar ones are excluded.

In population $M + N$, M is the number of the superior individuals in parent generation, while N represents the number of the individuals in the offspring population by elitism, the Hamming distance between individual x_i and x_j can be measured in accordance with the following formula:

$$y(i,j) = \left\| x_i - x_j \right\| = \sqrt{\sum_{k=1}^{M} \left(x_{ik} - x_{jk} \right)^2}, \quad i = 1, 2, \ldots, M + N - 1;$$

$$j = i + 1,\ i + 2, \ldots, M + N$$

The procedure of the niche technology: first, the Hamming distance between every two individuals is measured; and if the distance $y(i,j)$ is within the preset distance L, a larger penalty function is adopted to the individuals with worse fitness to lower their fitness, for which the inferior ones would be excluded during the process of evolution; the individuals in the population would be categorized after continuous crowding operation, accompanying with many small niches, which is favorable to maintain the population diversity and improve the distribution of the solutions. Niche technology guides the population to better development, which finally benefits global searching.

42.3.3 Algorithm Procedures

This paper applies two-dimensional annular topological structure, and the population structure adopted is Moore (as is shown in b of the Fig. 42.1), while Synchronous policies for updating the population.

The first step is to generate the initial population, which is then distributed in a two-dimensional annular structure. An individual is selected from among the neighbors of the central cellular by using roulette selection. The selected individual is crossed, generating new individual which is then mutated. The next step is the replacement operation: compare the new individual after mutation with the central cellular; the new individual replaces the central cellular if it is superior to the central cellular, if not, remain the central cellular. By combining the new offspring with the reserved N individuals in the parent generation, a new population named $M + N$ is formed. By calculating the individuals' fitness and ranking them, the neighboring individuals get into a niche. A larger penalty function is applied to the individuals with worse fitness to lower their fitness value. The former M superior individuals are reserved to be the population of next generation, while the former N individuals are to be the parent niche individuals for the next generation (Table 42.1).

42.4 Experiments and Analysis on Solving VRPTW Problem

42.4.1 Solving Procedures

1. Generate initial population randomly. The initial population is generated by encoding the nature number, and the coding individuals are presented in the order of the customers. Put "0" before and after the individuals; insert n−1 "0" among the individuals randomly, where n is the number of the vehicles. Figure 42.3 indicates that the delivery task for 8 customers is to be done by three vehicles, the route of the three vehicles are: delivery center 0 → customer (5 → 3 → 4) → delivery center 0; delivery center 0 → customer (8 → 1) → delivery center 0; delivery center 0 → customer (7 → 2 → 6) → delivery center 0.
2. Fitness function. Fitness function is used to measure the quality of the individuals and approximating degree toward the optimal solution. In formula (42.1), the objective function is composed of the vehicle's driving cost and the penalty cost. Let $K = \min D$, and the fitness function is $f = 1/K = 1/\min D$.
3. Selection operator. Select an individual from among the neighbors of the central cellular by using roulette selection.

Table 42.1 NCGA Pseudo-code

Algorithm Pseudo-code of the NCGA
1: proc Steps Up (NCGA)
2: cga.pop ← M individuals;
3: Ranking Fitness(cga.pop);Retaining the first N(N < M) individuals;
4: while not stop condition () do
5: for x ← 1 to Width do
6: for y ← 1 to Height do
7: n list ← Get Neighborhood (cga, position(x,y));
8: parents ← Locate Select(n list);
9: auxiliary individuals ← Crossover(cga,Pc,parents);
9: auxiliary individuals ← Crossover(cga,Pc,parents);
10: auxiliary individuals ← Mutation(cga,Pm, auxiliary, individuals);
11: Insert If Better(position(x,y), auxiliary individuals);
12: end for
13: end for
14: cga.pop ← auxiliary.pop;
15: Niche pop ← cga.pop plus N individuals;
16: Niche Fitness (Niche pop, distance parameter L.);
17: Ranking Fitness(Niche pop),Select (M,N) individuals;
18: cga pop ← M individuals;
19: Update Statistics(cga);
20: end while
21: end proc Steps Up

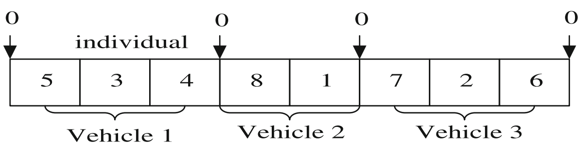

Fig. 42.3 Individual coding structure

4. Crossover operator. This paper introduces a new operator with which even two same parents can generate new individuals, which helps to avoid "premature" effectively. The crossover operator is named as order reversed crossover operator (ORX):

When there are two different parent individuals, set the two parent individuals: P1 :{28613754}; P2 :{54827136}, the procedures of the crossover individuals are:

(1) get two entry points randomly, and mark them with "|", like P1:{28 |613| 754}; P2:{54 |827| 136};
(2) the parts between the two entry points are reserved to the next generation, C1:{# # |613| # # #}, C2:{# # |827| # # #};
(3) delete the part that reserved C2 (8, 2, 7) from P1,then "61354" is gained; it becomes "45316" after reversion operation, and it is the same with P2;

(4) put “45316” into C2 in order, the newly gained offspring individual C2: 45827316; in the same way, C1: 72613845;

When the two parents are of same individuals, set P1:{48127653}; P2:{48127653}; by adopting the same method as that mentioned above, the offspring individuals gained are: C1: 35127684, C2: 35127684; therefore, it can be concluded that even two same parent individuals can still generate new offspring at the same time, which can avoid local optimal solution and thus avoid “premature”.

(5) Mutation operator. Reverse mutation operator is adopted in mutation process.
(6) Crowding Technology. Set crowding factors and adopts niche technology to re-rank the population.

42.4.2 Case Studies

This paper studies (Lin 2007) depot distribution problem with time windows. As for this problem, the main task is to deliver goods from a central depot to 8 customers; there are 3 vehicles with the capacity of 8 tons respectively, and the average speed of each vehicle is 50 km/h. The driving time of the vehicle is in proportion to the driving distance. Table 42.2 shows the tasks and the demands of each customer, while the distances between the central depot and the customers are presented in Table 42.3.

To evaluate how competitive NCGA is, a comparison of the algorithm with canonical cellular genetic algorithm (Alba and Bernabé 2008) and niche genetic algorithm (Wang et al. 2009) is made on optimizing the VRPTW model. The parameters setting are as follows: population size is 100, crossover probability $Pc = 0.8$, mutation probability $Pm = 0.05$, penalty coefficient a = b = 50 km there are 3 crowding factors, and the termination iterative time Generation = 100. There are 15 times of independent operation on each algorithm, and the optimized results obtained are presented in Table 42.4.

In Table 42.4, the average delivery distance gained by using niche cellular genetic algorithm is 933, that of canonical cellular genetic algorithm, niche genetic algorithm and Simple genetic algorithm are 976, 947 and 986 respectively, which means that niche cellular genetic algorithm performs better in solution accuracy.

Table 42.2 The tasks and demands of each customer

Customers	1	2	3	4	5	6	7	8
$q_i(t)$	2	1.5	4.5	3	1.5	4	2.5	3
$T(h)_i$	1	2	1	3	2	2.5	8	0.8
$[ST_i, ET_i]$	[1,4]	[4,6]	[1,2]	[4,7]	[3,5.5]	[2,5]	[5,8]	[1.5,4]

Table 42.3 The distances between the central depot and the customers

Customers	Distance/km								
	0	1	2	3	4	5	6	7	8
0	0	40	60	75	90	200	100	160	80
1	40	0	65	40	100	50	75	110	100
2	60	65	0	75	100	100	75	75	75
3	75	40	75	0	100	50	90	90	150
4	90	100	100	100	0	100	75	75	100
5	200	50	100	50	100	0	70	90	75
6	100	75	75	90	75	70	0	70	100
7	160	110	75	90	75	90	70	0	100
8	80	100	75	150	100	75	100	100	0

Table 42.4 The obtained results

Independent operation time	Delivery distance (km)			
	Niche cellular genetic algorithm	Canonical cellular genetic algorithm	Niche genetic algorithm	Simple genetic algorithm
1	975	1025	925	1010
2	910	960	960	1030
3	975	975	910	975
4	910	925	975	960
5	960	925	910	975
6	960	960	960	925
7	910	975	995	1025
8	910	960	960	1075
9	910	1000	910	975
10	910	910	960	960
11	960	960	925	925
12	910	1075	910	1000
13	910	975	975	1030
14	975	1030	960	995
15	910	1030	975	925
Mean value	933	976	947	986
Time for getting optimal value	9	1	3	0
Maximum/minimum	975/910	1075/910	995/910	1075/925

According to the comparison on optimal solution time and the maximum/minimum value, cellular can easily avoid local convergence and performs more stable, by which it can be concluded that the niche cellular genetic algorithm is of great efficiency in solving the vehicle routing problem with time windows.

42.5 Conclusion

As the vehicle routing problems with time windows are complex NP hard problems, this paper adopts a niche cellular genetic algorithm based on canonical cellular genetic algorithm and by introducing the niche technology so as to solve this kind problem more effectively. Meanwhile, a new order reversed crossover operator is proposed when solving the vehicle routing problem with time windows. The comparison with the other three genetic algorithms indicates that the new algorithm is of better accuracy and stability, and it is an effective method in solving the logistics distribution route optimization problems.

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Chapter 43
Capacity Linear Evaluation for Production Line Based on Production Course

Bing Chen, Ting Yang, Kai Liu and Shan Li

Abstract Production capacity is evaluated through analysis on production course in this paper. Firstly in order to simplify and describe the production line with complicated property, the manufacturing resources with close relations are accumulated into a manufacturing vertex. Consequently the directed network model is constructed. Secondly through analysis on the production course and performance state of manufacturing resources, the affecting factors and parametric definitions are given. Then the linear evaluation model of production capacity is built by means of defining the available capacity and load of manufacturing vertex. Finally the capacity evaluation constrained by limited manufacturing resources is solved by linear programming. And an actual aero-engine blade production line is regard as an example to validate the algorithms in this paper.

Keywords Directed network · Linear programming · Production capacity · Production line

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43.1 Introduction

With the fierce competition in discrete industry such as automobile, aircraft, aero-engine and machinery manufacturing, the enterprise need to develop with the high quality and low cost through the agile and rapid production. Therefore the mixed production is widely adapted to an implement format in most plants. Mixed production means to yield various products with different quantity in one production line (Song and Han 2002; Wang et al. 2009a). Because of complexity in structure, dynamic status of elements, multi-step in manufacturing process and flexibility in equipments configuration, doubtlessly mixed production line is a complicated system with all kinds of factors affecting each other.

Production capacity is defined as the maximum output of production line with all the manufacturing materials in a certain period. After the production line and manufacturing process have been designed, the production capacity is mostly determined by the relationship between the manufacturing resource and capacity requirement of products. Therefore capacity evaluation is to determine the maximum product-mix $x = (x_1, x_2, \ldots, x_m)$ of m products based on the manufacturing resource, operation schedule, product features and manufacturing resources.

Until now, many researchers have considered capacity evaluation, and recently many papers have been proposed. Now Theory of Constraints (TOC) heuristic algorithm (Nazari-Shirkouhi et al. 2010; Wang et al. 2009b), linear integer programming (Balakrishnan and Cheng 2000; Coman and Ronen 2000; Bhattacharya and Vasant 2007; Geng and Jiang 2007; Kai and Shabbir 2009), and some intelligent searching algorithms such as tabu search (Onwubolu 2001; Mishra and Tiwari 2005), genetic algorithms (Onwubolu and Mutingi 2001) are used commonly. All of them researched production capacity through confirming and maximum utilization the bottleneck of production line. Then the result of capacity evaluation might become the basis for assigning decision of product and resource.

But these researches were mostly focused on searching algorithms on maximum production capacity. And they all paid less attention to production course and the affecting factors on production capacity. The available capacity and capacity demand of products are only regarded as the known terms to be used directly. Moreover some of these papers achieved the maximum output of the production line with the certain product demand. But in the real world, the demand of products is very volatile and uncertain. Therefore in this paper under demand uncertainty the production capacity is studied base on analysis on production course, which mostly includes configuration of manufacturing resource, manufacturing process and manufacturing quality.

The paper is organized as follows. Directed network is introduced in Sect. 43.2. The production line is simplified to manufacturing vertices and directed edges. The production course and status of manufacturing resource are analyzed in detail. And the affecting factors are concluded and defined with some parameters in Sect. 43.3. The capacity evaluation model is proposed in Sect. 43.4 through definition about capacity demand of products and available capacity of vertices. In Sect. 43.5, an actual aero-engine blade production line is studied to exhibits the approaches to capacity research. The results are validated through production process simulation. Finally observations and open questions are concluded.

43.2 Directed Network Model of Production Line

Production line is composed of manufacturing resources, manuafcturing process, schedule planning and products. Production line manufacturing resouces, such as equipments, fixtures and hunman labors, will be gathered to the manufacturing unit to accomplish the manufacturing tasks. Since single manufacturing resource usually can't solely complete the manufacturing mission, the manufacturing unit is the basic element of capacity evualuation. But in the production line the manufacturing unit with the same manufacturing feature isn't unique, these manufacturing units can be defined as a manufacturing vertex (Fig. 43.1). All the manufacturing units of the vertex are equal and fair, and they have the same manufacturing capability.

Products execute their manufacturing behavior through flowing in manufacturing vertices. Therefore a route will appear passing the route from UX235, SAJO, …, to examination vertex and so on, as shown in Fig. 43.1. Then more products will come into being a directed network structure (Yang et al. 2010). Thus the production line can be simplified to manufacturing vertices and directed edges to describe the complicated production course.

Moreover, the basic elements in production line with m kinds of products and n manufacturing vertices might be defined as follow.

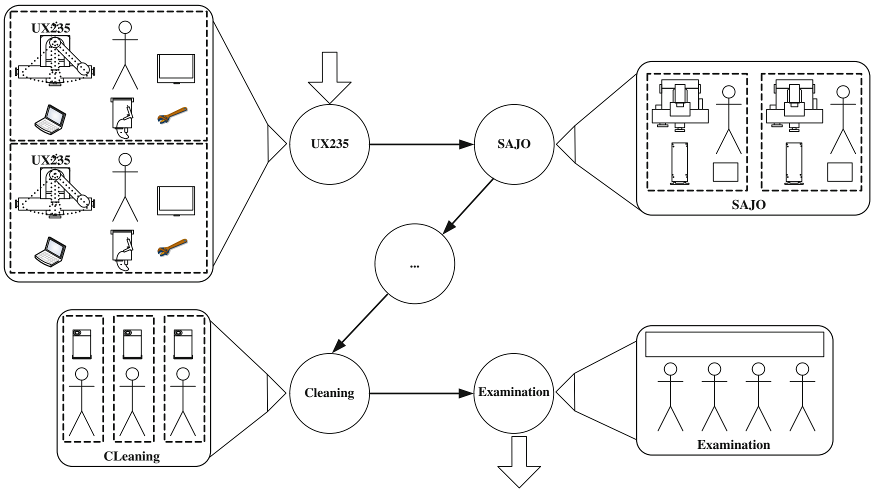


Fig. 43.1 Directed network model of production line

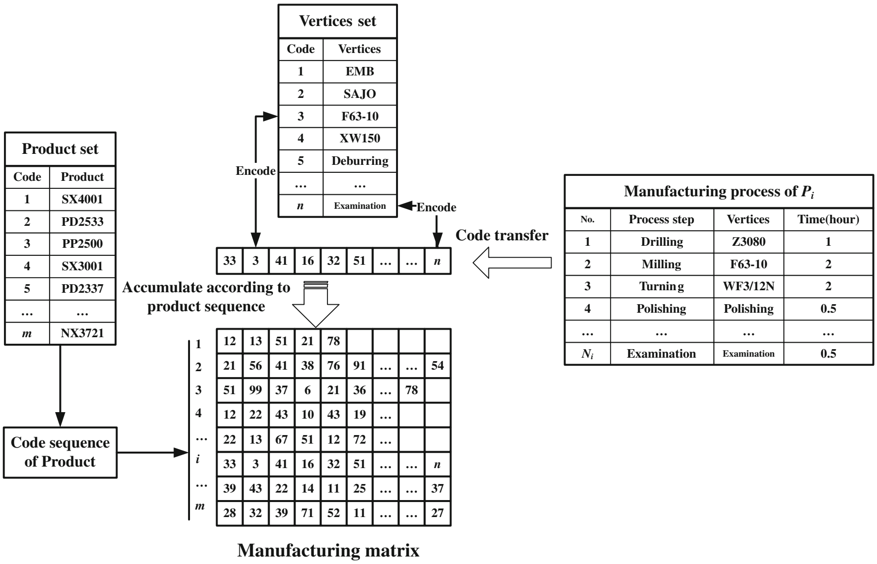


Fig. 43.2 Generation of manufacturing process matrix

(1) Products: the set $P\{P_i\}, (i = 1, \ldots, m)$ is used to describe products in production line.
(2) Manufacturing vertices: the set $V\{V_i\}(i = 1, \ldots, n)$ is defined as the n manufacturing vertices.
(3) Manufacturing process $Pr\{Pr|Pr_{ij} = V_k\}$, $(i = 1, \ldots, m, j = 1, \ldots N_i, k = 1, \ldots n)$ (N_i is the number of the manufacturing step of P_i): According to these definintions, as shown in Fig. 43.2, the products and manufaturing vertices can be encoded by integers from 1 to m and integers from 1 to n respectively. Then the manufacturing process of P_i is transformed to the corresponding code sequence [33 3 41 16 32 51 … n] in according with the code of manuafcturing vertices. Thus all the manufactruing procrsses in production line will constitute a process matrix in Fig. 43.3 (Onwubolu and Mutingi 2001). The element of manufacturing process matrix $Pr_{ij} = V_k$ represents the manufactring vertex where j manufacturing step of product i is processed.

In some sense manufacturing process is the power to drive production line to run. And it determines the whole topological architecture of production line network model, as mentioned previously. Moreover the production line will be described by product set, manufacturing vertices and manufacturing process matrix in mathematical sense.

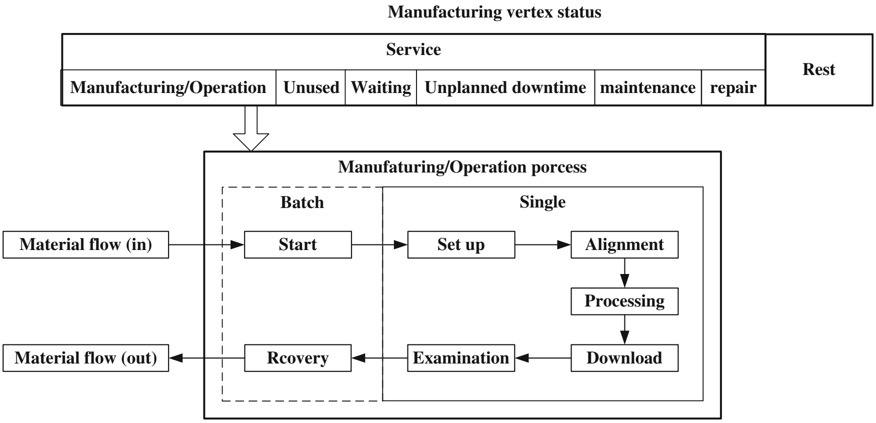


Fig. 43.3 Running process of manufacturing vertex

43.3 Analysis on Affecting Factors in Production Capacity

Production capacity is the basic property to depict the production line objectively. Consequently accurate description about production capacity must base on the analysis on production running and manufacturing behavior. For a typical manuafcturing unit the running process includes service and rest. And the service process involves manufacturing/operation, waiting, unused phase, planned maintenance and unplanned repair, as shown in Fig. 43.3.

Now the manufacturing/operation procedure will be analysed detailedly in Fig. 43.3. After one batch of products entering the manufaturing vertex through material flow system, the manufacturing mission is completed through starting, setting up, manuafcturing/operation, measuring during manufacturing, download, examination and recovery.

The output of production line also lies on the available capacity which the manufacturing vertices can be provided. The capacity of manufacturing vertex might be described as the available time. Then the available time is determined by the duration time when the product stays in the manufaturing vertex, which is affected by the manufacturing resource and their organization mode. For example, all the elements involved in vertex, such as the equipments, fixtures, tools, humans, working rule, working sequence and so on, might have effects on the available working time.

Therefore, the affecting factors of production line is analysed hierarchically in Fig. 43.4 according to its production crouse and dynamic behavior.

It can be seen that production capacity has a great number of affecting factors without independent one another in Fig. 43.4. And their relationships are very complicated. Hence they must be concluded and simplified to some parameter to decribe and define production capacity of the production line. These parameters are given as follow.

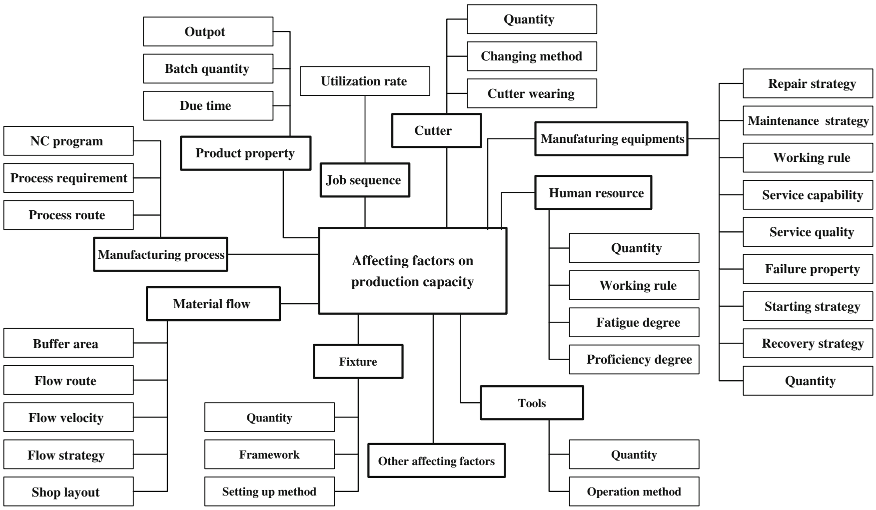


Fig. 43.4 Affecting factors on production capacity

(1) *w*: Due time of products (weeks). Week is be used as a unit of production line running up and planning.
(2) *Ts*: Service time (hours/week). Service time is defined as the time except the rest time every week, which is shown in Fig. 43.3.
(3) *Td*: Planned downtime (hours/week). Planned downtime includes the time of maintenance and changing cutter according to production plan. Moreover the start and recovery time, as shown in Fig. 43.3, is executed only once everyday in actural production. So these time is also involved in planned time.
(4) z: The multiplicity of manufacturing vertex. As mentioned in Sect. 43.2, manufacturing resource such as equipment, cutter, tool and so on consitute the manufacturing unit in certain proportion. Therefore the number of manufactruing unit within vertex is defined as the multiplicity of manufacturing vertex.
(5) α: Unplanned downtime (%). The downtime owing to stochastic failure of equipment and cutter is defined as unplanned downtime. Because the failure is stochastic, it is described in percentage.
(6) β: Utilization rate of manufacturing vertex (%). The waiting time owing to job schedule will waste the process capacity, so β is used to depict this course.
(7) ξ: Qualified rate of process step (%). The quality of product has close relationship with every step of the manufacturing process. Now the Process Capability Index (PCI) is a common technique to describe the processing quality based on statistics. Then the PCI can be transformed to qualified rate of the certain process step (Liu and Jiang 2009).
8) *Tm*: Manufacturing/operation time (hours/step). Manufacturing/operation time includes the manufacturing, operation and measuring time during manufacturing or operation, which is affected by processing capability of equipment, cutter wearing, NC program and process requirement. In production line the

geographical distance between manufacturing vertices is near, so the time of material flow is separated to the manufacturing/operation time.

(9) Products need alignment, to be set up and to be downloaded in the machine besides manuafturing/operation. So *Tsp*, *Tal* and *Tdl* are used to describe these steps.

43.4 Evaluation Model of Production Capacity

The capacity of production line is mostly determined by relationships between the available capacity of manufacturing resource and production capacity demand of all products. Available production capacity of manufacturing vertex is the available time which the manufacturing vertex can be provided in certain period. The available capacity is affacted by working sequence, property of manufacturing equipment, technical level of human, planned and unplanned downtime. Hence the avaliable production capacity *Ca* can be defined as Eq. (43.1).

$$Ca = z \times w \times (Ts - Td) \times \alpha \times \beta \tag{43.1}$$

Manufacturing vertices are responsobility for the manufacturing mission on process lever. So mission load on vertex must be achieved and regarded as the basis of production capacity. In this paper mission load is defined as the summation of time of all the manufacturing steps processed in certain vertex. At first the working time of the manufacturing process step is defined as Eq. (43.2).

$$Tp = \frac{Tm + Tsp + Tal + Tdl}{\xi} \tag{43.2}$$

where *Tp* is related to the certain process step, the manufacturing process matrix in Fig. 43.3 is transform to $Pr\{Pr|Pr_{ij} = (V_k, Tp_j)\}$, $(i = 1, \ldots, m, j = 1, \ldots N_i, k = 1, \ldots n)$, through adding the working time to the element.

Then when the product-mix is $x = (x_1, x_2 \ldots x_m)$, through traversing the manufacturing process matrix the mission load of the manufacturing vertex V_k is defined in Eq. (43.3):

$$\begin{aligned} L_k &= \sum_{(Pr_{ij}(1)=V_k)i=1,j=1}^{i=m,j=N_i} x_i Tp_{ij} = \sum_{(Pr_{ij}(1)=V_k),i=1,j=1}^{i=m,j=N_i} x_i Pr_{ij}(2) \\ &= \sum_{(Pr_{ij}(1)=V_k),i=1,j=1}^{i=m,j=N_i} x_i \frac{Tm_{ij} + Tsp_{ij} + Tal_{ij} + Tdl_{ij}}{\xi_{ij}} = k = 1, \ldots, n \end{aligned} \tag{43.3}$$

And the corresponding algorithm is shown as in Table 43.1.

The load rate of the manufacturing vertex is defined as the proportion of mission load to available capacity, which is defined by Eq. (43.4):

Table 43.1 Algorithm of mission load

Input: Manufacturing process matrix Pr and Product set P
for $1 \le i \le m$
for $1 \le j \le N_i$
if Pr_{ij} (1) = V_k;
$L_k = L_k + Tp_{ij} = L_k + Pr_{ij}(2)$;
end
end
end
Return: L

$$\theta_k = \frac{L_k(x)}{Ca_k} \times 100\,\% \tag{43.4}$$

Obviously only when the load rate is less than 100 %, the manufacturing mission can be completed. Therefore the optimization model of production capacity evaluation is built as Eq. (43.5):

$$Max\left(\sum_{i=1}^{m} x_i\right) \tag{43.5}$$

$$\text{s.t.} \qquad x_i \in Z^+ \quad i = 1, \ldots, m \tag{43.6}$$

$$\theta_j \le 100\,\% \quad j = 1, \ldots, n \tag{43.7}$$

$$\min(x_i) \ge Q \quad i = 1, \ldots, m \tag{43.8}$$

Equation (43.6) describes the output is positive integer. Equation (43.7) is to ensure the mission can be completed in the given period. Equation (43.8) is set the minimum output of products to ensure basic benefit of each product.

In the optimization model the product-mix is unknown, so the model needs to be modified farther. Firstly the load rate of manufacturing vertex V_j when output of product is 1 and all the other products is 0 (x = (0, …, 0, 1, 0, …, 0), x_i = 1) is defined as θ_{ij} in Eq. (43.9).

$$\theta_{ij} = \frac{\sum_{(Pr_{ik}(1)=V_j),k=1}^{k=N_i} Tp_{ik}}{Ca_j} \times 100\,\% \quad i = 1, \ldots, m \quad j = 1, \ldots, n \tag{43.9}$$

Then the load rate matrix $[\theta]$ can be obtained as Eq. (43.10):

$$[\theta] = \begin{bmatrix} \theta_{11} & \theta_{12} & \cdots & \theta_{1n} \\ \theta_{21} & \theta_{22} & \cdots & \theta_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \theta_{m1} & \theta_{m2} & \cdots & \theta_{mn} \end{bmatrix} \tag{43.10}$$

Therefore, the load rate of the manufacturing vertices with product-mix $x = (x_1, x_2, \ldots, x_m)$ can be computed by Eq. (43.11):

$$\theta(x) = [\,\theta_1 \quad \theta_2 \quad \cdots \quad \theta_n\,]^T = \begin{bmatrix} \theta_{11} & \theta_{12} & \cdots & \theta_{1n} \\ \theta_{21} & \theta_{22} & \cdots & \theta_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \theta_{m1} & \theta_{m2} & \cdots & \theta_{mn} \end{bmatrix}^T [\,x_1 \quad x_2 \quad \cdots \quad x_m\,]^T \tag{43.11}$$

Equation (43.11) is used to compute the load rate in Eq. (43.7). Then the optimization model is a problem of integer linear programming. Now there are some mature algorithms and software to solve linear programming, so the solving methods mightn't be described detailed yet in this paper.

43.5 Evaluation Model of Production Capacity

An actual aero-engine blade production line is introduced as an example to validate algorithm proposed in the paper. The blade production line is a typical discrete production line with complicated property. The blade has complicated geometrical shape, and the precision requirement of blade is very high. Moreover its manufacturing process has many steps and related to many manufacturing vertices. The example of this paper has 41 manufacturing vertices and yields 15 kinds of blades. The production evaluation is carried out in 9 weeks. All the manufacturing vertices perform according to the certain working sequence. For example the vertex UX235 rests in the Sunday and in other time its working sequence is shown in Table 43.2.

Then the service time Ts of UX235 is

$$2 \times 4 \times 6 = 48 \text{ h/week}$$

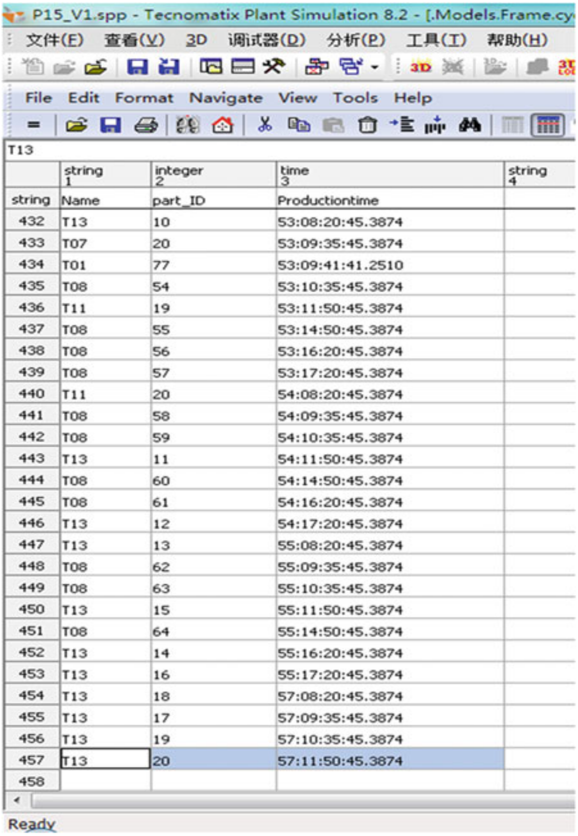
The planned service time Td is

$$2 \times 0.5 \times 6 = 6 \text{ h/week}$$

Furthermore the minimum output Q in Eq. (43.8) is set to 20. The basic configuration and data of production line such as unplanned downtime, utilization rate and qualified rate of process step can be obtained by statistical analysis on the history records.

Table 43.2 Working sequence

Item	Content
Shift	2
Service time	4 h/shift
Planned time	0.5 h/shift



	string 1	integer 2	time 3	string 4
string	Name	part_ID	Productiontime	
432	T13	10	53:08:20:45.3874	
433	T07	20	53:09:35:45.3874	
434	T01	77	53:09:41:41.2510	
435	T08	54	53:10:35:45.3874	
436	T11	19	53:11:50:45.3874	
437	T08	55	53:14:50:45.3874	
438	T08	56	53:16:20:45.3874	
439	T08	57	53:17:20:45.3874	
440	T11	20	54:08:20:45.3874	
441	T08	58	54:09:35:45.3874	
442	T08	59	54:10:35:45.3874	
443	T13	11	54:11:50:45.3874	
444	T08	60	54:14:50:45.3874	
445	T08	61	54:16:20:45.3874	
446	T13	12	54:17:20:45.3874	
447	T13	13	55:08:20:45.3874	
448	T08	62	55:09:35:45.3874	
449	T08	63	55:10:35:45.3874	
450	T13	15	55:11:50:45.3874	
451	T08	64	55:14:50:45.3874	
452	T13	14	55:16:20:45.3874	
453	T13	16	55:17:20:45.3874	
454	T13	18	57:08:20:45.3874	
455	T13	17	57:09:35:45.3874	
456	T13	19	57:10:35:45.3874	
457	T13	20	57:11:50:45.3874	
458				

Fig. 43.5 The simulation result of production cycle

Then the optimization model in Sect. 43.4 is solved by means of branch-and-bound method in mathematic sense (Vladimir et al. 1998). Finally the maximum general output is 457 and the corresponding product-mix is [77, 20, 43, 26, 20, 20, 20, 64, 20, 47, 20, 20, 20, 20, 20]. It is regarded as the production plan. Then the complete time of production mission of all the 457 products is not more than 57 days and 11 h and 50 min in Fig. 43.5, which don't exceed the given time 9 weeks. So the result is reasonable.

43.6 Conclusion

Capacity evaluation for production line is a complicated problem. In this paper production capacity is researched based on analysis on production course. Then the affecting factors can be given in hierarchy. These factors are concluded to describe the capacity demand and available capacity. Then the linear evaluation model is built and the result of maximum product-mix is achieved. Finally the production course simulation proves the result reasonable. In further research the parameters of affecting factors will be studied in detail for more accurate description.

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Chapter 44
Classification and Balancing of an Automotive Assembly Line

Shaheen Perween, Asim Zaheer and Rameez Khalid

Abstract Assembly line balancing (ALB) is the optimal segmentation of assembly tasks with respect to a decided objective. Assembly line balancing problem (ALBP) is usually a multi-objective problem which includes minimization of number of stations, resources, cycle time, cost and the maximization of efficiency and profit. Although a number of assembly line balancing algorithms are available but the solution to multi-objective balancing problem of the real world are still needed. Many researchers have contributed to fill the gap between the real world problems by proposing suitable optimization models. A number of others have proposed a classification scheme for the ALB. In this paper we classify an assembly line of an automotive manufacturing industry, which is the very first effort in this area in Pakistan. The line is then balanced with an objective function of interest.

Keywords Assembly lines · Assembly line balancing problem (ALBP) · Classification · Manufacturing industry

44.1 Introduction

Assembly lines are production systems developed to meet, in a broader perspective, the requirements of mankind (Baskak et al. 2008). Manual Assembly line was introduced by Ford motor company in 1913 for the assembly of their famous

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model T Ford, the results were so appreciating that forced other assemblers to imitate the same method (Groover 2008). The success of assembly lines did not stop at automotive manufacturing; it quickly spread to a variety of products: audio equipment, refrigerators, washing machines, television sets, furniture etc.

Pakistan's automotive industry is not the most prominent in the world, it sprouts back in the early 1950s (Ahmed 1991) and continue to grow in a slower pace until in the early 1970s when a programme for the local development of the automotive parts was initiated. In the year 1972, Pakistan Automobile Corporation (PACO) was established to develop the automobile industry. In the year 1984, PACO launched the Suzuki Project in technical cooperation agreement with Suzuki Motor Company, Japan which started its production in 1984. Finally in the next years, Pakistan auto-industry started operating under franchise and technical cooperation agreement with Japan, Korea, Europe and China (Jawed 2011).

From early 1950s to 2011 the automotive sector saw a number of rises and falls mainly because of government policies. Automobile sales touched the record value in 2006, 2007 due to the availability of financing schemes with low interest rates and rural buying. Since then it is striving hard to reach the same value.

In contrast with the 4-wheelers, sales of 2-wheelers remains on increasing trend because of the import of low cost motorbikes and rising fuel prices (Khan 2012). This brings in an environment of competition among the assemblers of 2-wheelers. Major impact is the cost, as these are much cheaper than local assembled ones of other origin. Since motorbike manufacturing industries have achieved more than 80 % localisation, most of the parts used in assembly are from local vendors (Administrator A 2010).

Pakistan started the export of locally developed bikes in the year 2008 to developing countries (Afghanistan, Somalia, Bangladesh, Kenya and Sri Lanka) for which, Pakistan is getting a tough competition from manufacturers of neighbouring countries in its region (India and China) (Administrator A 2010). To remain competitive Pakistan's local assemblers need to work on the major issues related to cost, quality and productivity.

The current condition of local assemblers and vendors in Pakistan is such that they do not have an adequate and up-to-date knowledge of line balancing techniques except for some multi-nationals. Some of them are reluctant to redesign or rebalance the assembly line since they do not have the knowledge of its benefits; others fear that it will cost time and money or consider it as a waste. The focus of this research is to change this mindset and to impart recent research of classification, line balancing techniques and its application. Furthermore, a vendor industry's assembly line was selected, classified and rebalanced, and shared here to set a precedent.

The structure of this paper is such that in Sect. 44.2, assembly line balancing and classification techniques are discussed. Section 44.3 is devoted to the problem statement and its solution. Results and future issues are reported in Sect. 44.4.

44.2 Context

44.2.1 Assembly Line (AL) and its Classification

An assembly line is a collection of workstations where assembly tasks are performed. The work piece moves from station to station. Assembly operation of the product is divided into hundreds or thousands of elementary operations as tasks or work elements. On an assembly line, tasks are grouped together into a number of major operations performed at different workstations. These workstations are arranged in sequence of the precedence of major operations, whereas at workstations, task precedence is followed. Figure 44.1 shows the breakup of an assembly operation (with Number of Tasks = n = 11 tasks) (Boysen et al. 2007).

Owing to the versatility of human workers, assembly lines can systematize the production in three different manners or type of layout.

A single model line produces only one product in large quantities. This type of arrangement is used for products with very high demand. Batch model and mixed-model lines are designed to produce two or more products at a time. For batch model line, the line is set for the first model then the stations are reconfigured to produce the next model. In the case of mixed model, number of products are made simultaneously on the same line (Groover 2008).

44.2.2 Assembly Line Balancing Problem (ALBP) and its Classification

Assembly line balancing is the optimal grouping of assembly tasks. A feasible grouping is such that the sum of task times assigned to each workstation is nearly equal to the required fixed cycle time. A usual objective of ALB is maximization of line utilization, which is measured by line efficiency E as productive fraction of line's total service time $\sum T_{si}$ and directly depends on T_C and number of stations m (Kriengkorakot and Pianthong 2007).

$$E = \sum T_{si} \Big/ (m \times c) \tag{44.1}$$

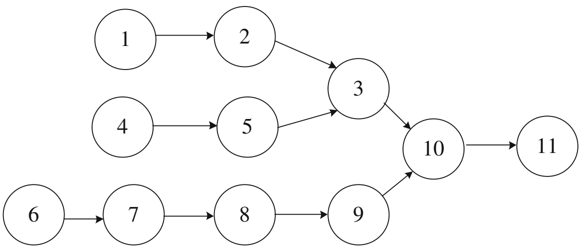

Fig. 44 1 Precedence Diagram

For the last several decades assembly lines and assembly lines related issues have been a major research area and the centre of interest for operation management community. Bryton, in 1954, conducted the first attempt in ALBP as discussed in his graduate thesis (Baskak et al. 2008). Whereas the very first published research paper that discussed the ALBP was by Salveson (1955), who presented linear programming as a mathematical formulation of the problem and suggested a solution procedure (Bahalke et al. 2011; Dolgui et al. 2002).

ALBP is an optimization problem, guided by some objectives like minimization of cycle time or number of workstations etc., in some cases a multi-objective optimization is also worked out (Scholl and Becker 2006).

Decision to set a new component AL or to rebalance an existing one is a long term decision. Before rebalancing or designing a new AL, a practitioner should have complete knowledge of characteristics and design of ALs. Cost and system reliability, task nature, resource selection, task precedence constraints, ALs structure (orientation), inventory supply and control, work transport system and buffer allocation systems are among the most important factors of concern (Kamal Uddin et al. 2010).

Assembly lines are characterised with respect to assembly constraints i.e., layout types, objective functions and design constraints. The simplest form of ALBP is defined by Baybars as Simple assembly line balancing problem (SALBP), which considers task precedence constraints only. By the introduction of other restrictions the ALBP becomes General assembly line balancing problem (GALBP).

Ghosh and Gagnon makes use of the important characteristic to define an AL which is layout types (discussed in Sect. 44.2.2), variations in task processing time and assembly constraints and were the first to classify the ALBP in four major categories (Kriengkorakot and Pianthong 2007). The categories are single model deterministic (SMD), single model stochastic (SMS), mixed-model deterministic (MMD) and mixed-model stochastic (MMS) ALs (Kriengkorakot and Pianthong 2007; Scholl and Becker 2006; Brahim and Delchambre 2006).

Classification scheme provided by Ghosh and Gagnon does not provide a systematic approach which enables researchers to identify and classify an assembly line with reference to its characteristics. Scholl and Becker classified the assembly lines by considering assignment restrictions, station and line characteristics and objective function criteria in ALB, and defined two major types of ALBP (Kriengkorakot and Pianthong 2007; Scholl and Becker 2006).

From this survey of classification criteria of ALBPs it is very lucid to deduce that none of the researchers, Baybars et al. Ghosh and Gagnon and Scholl and Becker were able to provide any uniform standardized method to classify the ALBPs. The necessary requirement towards the best solution of ALBP is to classify the ALBPs and compare problems and solutions with what is covered by researchers and practitioners in the available literature. This is exactly what we have done in this paper.

44.2.3 Classification Scheme for ALBP

To narrow down the widened gap between researchers and practitioners, Boysen et al. have introduced a classification scheme to classify the research area of ALBP. The basic classification scheme is inspired by the widely accepted classification scheme for machine scheduling by Graham et al. 1979, for which they introduced a 3-field problem classification criteria and utilize Greek letters α, β and γ as three basic elements for the classification. This criteria was also used by (Brucker et al. 1999) for the classification of project scheduling and employs the tuple notation.

Boysen et al. 2007 make an efficient use of similarities between machine scheduling, project scheduling and ALB, to introduce the classification scheme based on tuple notation [$\alpha|\beta|\gamma$] for ALBPs. Comparisons of basic elements for different problems are shown in Table 44.1. This classification scheme provides decisive solution alternatives that depend on production approaches, constraints and objectives. This classification scheme was utilized to classify the assembly line selected and presented in the next section of this paper.

ALBP falls into the category of combinatorial optimization problems, and do not guarantee an optimal solution for problems of significant size. Therefore, after the first attempt by Salveson, there have been various methods developed to solve the different types of ALBPs and are still being carried out till today.

Heuristic methods became popular techniques to solve an ALBP. Most of them are task oriented and based on the simple priority rules which provide a few feasible number of solutions. Among the most popular heuristics are Ranked positional weight, Number of followers, Number of immediate followers, Number of predecessors and Work element time (Waldemar 2011).

For the solution of a large scale ALBP, researchers have developed meta-heuristic methods based on genetic algorithm, simulated annealing, tabu search and ant system approach (BaykasoğluAdil 2009; Lapierre et al. 2006; McMullen and Frazier 1998)

Table 44.1 Comparision of classification schjemes

Classification schemes	α Restrictions	β Work characteristics	γ Target
Machine scheduling problem by Graham et al. (Graham et al. 1979)	Machine environment	Job characteristics	Optimality criteria
Project scheduling problem by (Brucker et al. 1999)	Resource environment	Activity characteristics	Objective function
ALBP by (Boysen et al. 2007)	Precedence graph characteristics	Station and line characteristics	Objectives

44.3 Problem Statement

The objective of our research is to link Pakistan's automotive sector with latest research in field of ALBP. For this purpose, a muffler AL was selected that belongs to a vendor industry of automotive parts. Their major products include Mufflers, Rims, Handles, Spokes and Nipples for world renowned 2-wheelers. Initial survey of industry unveils that there is a huge gap between the findings of academic research and their current practises, i.e. whatever they were performing in the industry is based on their intuition and little portion of it follows the standard procedures or latest research.

The contribution of our study is twofold. Firstly, the study of selected AL was carried out and a compact tuple was then developed. This was done for the better understanding of the assembly line and relevant issues. It also gave an opportunity to compare our problem with the information available in literature, and to search for solutions adopted by different researchers for similar conditions. Secondly, search for the most feasible solution for our objective. As this is one of the very first attempts, it is expected that it will surely open new avenues for improvement in Pakistan's automotive sector.

Here, we present a brief introduction of the selected muffler assembly line. The production of muffler assembly involves four main operations: shearing, rolling, assembling and chrome plating. The scope of our study includes the operations starting from shearing to the complete assembly of muffler. Currently these operations are performed in batches. After a careful study of the muffler assembly line the identified problems were: too many work stations, bottle necks, unnecessary work in process (WIP), improper plant layout, unnecessary transportation and low line efficiency.

For classification of this assembly line, we referred to the scheme provided by Nils Boysen et al. 2007. After the selections of Precedence graph characteristic (α), Station and line characteristics (β) and Objectives (γ) for muffler AL, data are submitted in ALB Classificatory which is available at Assembly Line Balancing homepage (Armin et al. 2012). This will represent the problem in compact and readable manner i.e. tuple [$\alpha|\beta|\gamma$], using binary encoding which helps us in quick retrieval of similar problems and their solutions. Resulting Tuple is:

$$\text{ALB}[\text{link, fix}|\text{unpac, buffer}|E]$$

The above formulated tuple provides us with a readable format of our assembly line. The first portion of this formulated tuple shows that the stations are linked and fixed; the second portion shows that the stations are unpaced and there is a buffer between the stations; the last portion states our objective i.e. improvement in line efficiency. Further detail are discussed by (Boysen et al. 2007).

After the classification of the selected AL, we used a heuristic to minimize the number of work stations for the given cycle time. The complete AL of muffler consisted of 18 stations. Their standard times and precedence relations are listed in

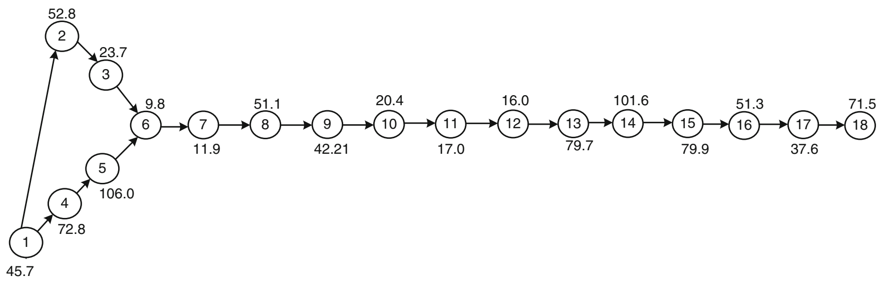

Fig. 44.2 Precedence relationship with work stations and respective standard times of Muffler Assembly Line

Fig. 44.2. The cycle time $T_{C,}$ and minimum number of stations are decided through (44.2, 44.3 and 44.4) defined below (Baskak et al. 2008):

$$\text{Cycle Time } (T_c) = \frac{\text{Working Time per Day}}{\text{Units Produced per Day}} \tag{44.2}$$

where, in this case:

Working Time per Day = 480 min = 28,800 s
Units Produced per Day = 246 mufflers per day
$T_{C,\ min}$ = 117 s per muffler

$$m_{min} = \text{Max.}(m_{min}, m_{probable}) \tag{44.3}$$

$$m_{min} = \sum t_i \Big/ T_c \tag{44.4}$$

where,

t_i = Summation of all task time = 891 s
m_{min} = 8 stations
$m_{probable}$ = count of tasks with condition $t_i > T_C/2$.
$m_{probable}$ = 117/2 = 58.5 s, there are 6 values (i.e. 72.8, 106, 79.7, 101.6, 79.9, 70.5)
m_{min} = Max. (m_{min}, $m_{probable}$) = Max. (8, 6) = 8 stations

After classification, the solution to ALBP is determined by "Ranked positional weight" method. Helgeson and Brine from General Electrical Company has developed the Rank positional weight technique in 1961. This procedure is applied in order to assign weights to tasks as defined in (Baskak et al. 2008) and (Dolgui et al. 2002).

Solution to the problem for rank positional weight method is computed through POM for window by Howard J. Weiss and the line is balanced with 10 workstations as in bar graph (Fig. 44.3) and solution summary to the problem (Table 44.2)

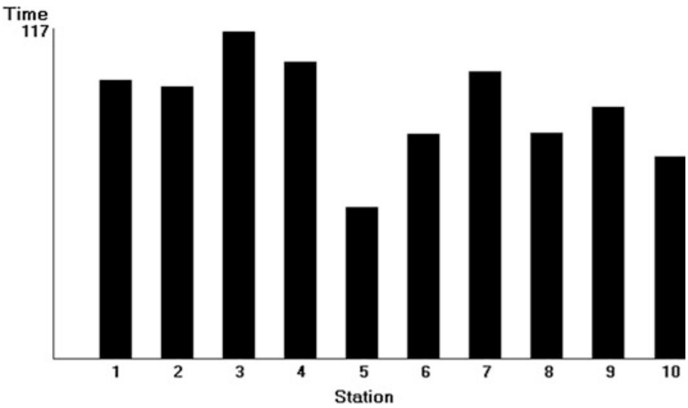

Fig. 44.3 Balancing results with Tc = 117 s

Table 44.2 Summary statistics for balancing of muffler assembly line

Performance criterion	Response before	Response after	Unit
Cycle time	117	106	seconds
Time allocated (cyc*sta)	1170	1060	sec/cycle
Time needed (sum task)	890.9	890.99	sec/unit
Idle time (allocated-needed)	279.1	169.00	sec/cycle
Efficiency (needed/allocated)	76.14 %	84.05 %	
Balance delay (1-efficiency)	23.85 %	15.94 %	
Min (theoretical) Number of stations	8	9	

when T_C is 117 s. Figure 44.3 identifies and Table 44.2 presents that there is a total of 279.1 s of idle time available whereas the maximum idle time at a station is 65.7 s which is workstation number 9. The presence of idle time reduces the line efficiency to 76 %. The line is again rebalanced keeping the largest operation time as $T_C = 106$ s. Here, the number of stations remains the same whereas the idle time is reduced to a total of 169 s. The maximum idle time on a station is 34.5 s, and the line efficiency increased to 84 % (Fig. 44.4).

44.4 Results

For the first time in Pakistan, we have formalized and developed the compact and readable tuple notation for ALBP. This exercise surely reduces the gap between the practitioners and researchers as it involves both parties in a beneficial, healthy and fruitful investigation for the problem area. The comparison of the problem and the available solution from the data bank gives an opportunity for both the parties to rethink the possibilities and to strive for the most optimized solution. Here in

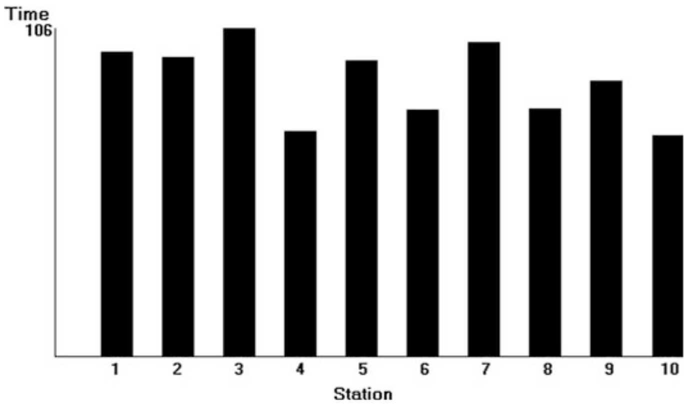

Fig. 44.4 Balancing results with Tc = 106 s

our problem, we have increased the efficiency of the assembly line by reducing the idle time solution and we have reduced the number of work stations from 18 to 10 on given cycle time i.e. $T_c = 117$ s. Therefore, we increased the efficiency from 46 to 76 %

44.5 Conclusion and Future Work

In this study, we have developed tuple and analysed the different conditions of assembly line having different cycle times and different number of stations. We found out that the theoretical minimum number of stations is 8, but through rank positional weight method we discovered that the actual number of work stations are 10 at given cycle time $T_c = 117$ s and line efficiency is 76 %. Careful analysis shows that each station has some idle time which needs to be adjusted. By changing the cycle time to 106 s we have reduced and eliminated the idle time at some stations. In future, we will further divide the task into sub task so that their cycle time is reduced which will result in a decrease in the number of stations, and an increase in efficiency.

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Chapter 45
Disruption Management for the Single Level Capacitated Dynamic Lot-Sizing Problem

Hui-min Ma, Meng-jun Xu and Shuang Zhang

Abstract Focused on the single level capacitated dynamic lot-sizing problem which suffered disruptions, the methodology of disruption management was applied to solve the problem. Based on the problem state that the demand of a customer was changed, a disruption recovery model was constructed, which took the deviation of the plan and the production cost into considerations. Then a knowledge evolution algorithm was presented to solve this model. By contrast with the method of re-scheduling, the simulation results demonstrated the feasibility and validity of the proposed model.

Keywords Demand changing · Disruption management · Knowledge evolution algorithm · Lot-sizing problem

45.1 Introduction

The lot-sizing problem is a crucial problem in MRP II system, which schedules the production quantity in a given planning period, and concerns the economic benefits of enterprises. The previous researches of the lot-sizing problem are mainly on certain problems, which have formed a set of a relatively complete theoretical

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system, including the classification of the lot-sizing problem (Tang 1998), the construction of the mathematical models (Han 2011). A lot of excellent algorithms (Okhrin and Richter 2011) have been put forward, and the recent researches focus is on improving the efficiency of the algorithms, including researches of parallel algorithms (Zhang et al. 2010), etc.

However, the uncertainties of the objective world tend to cause different disturbance to enterprises, which result in the original plan infeasible, and bring greater difficulty to the lot-sizing problem. Therefore, the research of uncertain lot-sizing problem gradually becomes an active research subject these years. Currently, researches of this field focus on the application of stochastic programming (Guan and Liu 2010) and fuzzy programming (Huang and Chen 2012) theory. These methods rely heavily on the past data statistics and the occurrence probability prediction of disruption events, which leads to deviations between the plan and practical application easily and difficult to achieve the ideal optimization.

Therefore, a real-time optimal method should be adopted to manage the lot-sizing problem which suffers disruptions, such as re-scheduling. Although this method can achieve the lowest cost, it is a global adjustment to the original plan, and the adjustment plan tends to cause excessive cost in implementation process, sometimes even not feasible. Consequently, in order to minimize the system disturbance, it is essential for the enterprises to generate a new plan by local optimization. This is exactly the basic connotation of disruption management.

The disruption management (Yu and Qi 2004) is a methodology of managing disruption events in real-time. Recently, the method has become an advanced research in the international academic, which involves many domains, such as aviation (Clausen et al. 2010; Kohl et al. 2007), project management (Zhu et al. 2005), logistics distribution (Hu and Sun 2012; Hu et al. 2011), and has important scientific significance and broad application prospect.

Therefore, based on the theory of disruption management, this paper takes the customer demand changing which always occurs in the manufacturing process as a research foundation, constructs a disruption recovery model of the single level capacitated dynamic lot-sizing problem, and presents the knowledge evolution algorithm to solve this model.

45.2 The Disruption Management Model of Customer Demand Changing

45.2.1 A Description of the Problem

This paper studies the disruption event that the customer demand changing. When the disruption occurs, the enterprises should respond to the changes rapidly, and work out an adjustment plan that can reduce the cost as much as possible under the premise of minimizing the whole system disturbance.

In the original lot-sizing problem, each item is produced according to the plan, and the customer demand can be satisfied. Assuming that the information of customer demand changing is received in $T_0(T_0 < T)$ period during the plan execution, and the plan becomes not feasible. Therefore, a rescue plan must be worked out rapidly. On this occasion, the original plan is adjusted locally to meet the customer demand with the condition of no shortage and no overtime.

45.2.2 Disturbance Measure

The key to construct a disruption management model is that how to measure the disturbance of the disruption events to the system, which plays a decisive role in the effect of the disruption management. This paper is to measure the disturbance in the following two aspects.

(1) Deviation of the plan. There are two parts to measure the deviation of the plan. One is the change time of the production plan of each item in each period, expressed in K_{it}. The other is the change of production quantity of each item in each period, expressed in $\left|Q_{it} - Q_{it}^0\right|$.
(2) Total cost, which is the same as the objective function of the original lot-sizing problem. The cost is another important factor which the enterprises pay attention to. Therefore, based on the theory of the disruption management, the paper is on the purpose of saving cost as much as possible for the enterprises while pursuing the smallest system disturbance when handling the customer demand changing.

45.2.3 The Disruption Management Model

The paper studies the single level capacitated dynamic lot-sizing problem which suffers disruptions. The lot-sizing problem discussed in this paper is based on the following assumptions: (1) The production lead time is zero. (2) Out of stock is not allowed, that is the customer demand in each period must be satisfied. (3) Without overtime. The disruption recovery model is given as follows.

$$\text{P1: } \min\left(\sum_{i=1}^{I}\sum_{t=T_0+1}^{T}\alpha K_{it} + \sum_{i=1}^{I}\sum_{t=T_0+1}^{T}\beta\left|Q_{it} - Q_{it}^0\right|\right) \tag{45.1}$$

$$\text{P2: } \min\left(\sum_{i=1}^{I}\sum_{t=T_0+1}^{T}\left(P_{it}Q_{it} + S_{it}Y_{it} + H_{it}I_{it}\right)\right) \tag{45.2}$$

s.t.

$$I_{i,t-1} + Q_{it} - I_{it} = d_{it} \quad i = 1, 2, \ldots, I; \quad t = T_0 + 1, \ldots, T \tag{45.3}$$

$$\sum_{i=1}^{I} a_{ij} Y_{it} + b_{ij} Q_{it} \le C_{jt} \quad j = 1, 2, \ldots, R; \quad t = T_0 + 1, \ldots, T \tag{45.4}$$

$$Q_{it} \le MY_{it} \qquad i = 1, 2, \ldots, I; \quad t = T_0 + 1, \ldots, T \tag{45.5}$$

$$\left| Q_{it} - Q_{it}^0 \right| \le MK_{it} \qquad i = 1, 2, \ldots, I; \quad t = T_0 + 1, \ldots, T \tag{45.6}$$

$$Y_{it} \in \{0, 1\} \qquad i = 1, 2, \ldots, I; \quad t = T_0 + 1, \ldots, T \tag{45.7}$$

$$K_{it} \in \{0, 1\} \qquad i = 1, 2, \ldots, I; \quad t = T_0 + 1, \ldots, T \tag{45.8}$$

$$Q_{it} \ge 0 \qquad i = 1, 2, \ldots, I; \quad t = T_0 + 1, \ldots, T \tag{45.9}$$

$$I_{it} \ge 0 \qquad i = 1, 2, \ldots, I; \quad t = T_0 + 1, \ldots, T \tag{45.10}$$

Objective function (45.1) minimizes the deviation between the new plan and the original one. Objective function (45.2) minimizes the total cost. Equation (45.3) is the demand balance equation. Equation (45.4) is capacity constraints. Equation (45.5) guarantees that only when the production quantity is greater than zero can the setup cost and preparing time be calculated. Equation (45.6) guarantees that only when the new plan is different from the original one does the system have disturbance. Equation (45.7) guaranties that Y is the binary value. Equation (45.8) guaranties that K is the binary value. Equation (45.9) guaranties that the production quantity is more than zero. Equation (45.10) guaranties the condition that no shortage.

45.3 The Solving Algorithm for the Disruption Management Model

Knowledge evolution algorithm (Ma et al. 2009) is a new intelligent optimization algorithm derived from Popper's Three Worlds theory and the characteristics of knowledge evolution, which is composed of one knowledge space and a number of group space. Currently, the algorithm has been applied in solving many NP-hard problems, such as the knapsack problem, capacitated dynamic lot-sizing problem in group technology cell and coordinated production-purchase planning problem, etc.

45.3.1 Code

In order to be applied to the disruption problem, the critical issue for knowledge evolution algorithm is how to code. In this paper, Y_{it} is designed as the hypothesis of binary value; Q_{it} is computed by (45.11) to (45.14); I_{it} and K_{it} are computed by (45.15) to (45.16). $I_i^{T_0} = I_{iT_0}$ is the inventory for item i in the end of period T_0. The specific coding scheme is as follows.

Each hypothesis of individuals denotes the solution of the lot-sizing problem. $X_{n,h}^k = x_{n,h,i,t}^k$ $(n = 1, 2, \ldots, N;\ \ h = 1, 2, \ldots, H_n;\ \ k = 0, 1, \ldots, K;\ \ i = 1, 2, \ldots, I;\ \ t = T_0 + 1, \ldots, T)$ is the binary value. $x_{n,h,i,t}^k = 0$ denotes item i isn't produced in period t, otherwise, denotes be produced. $P_{n,h}^k = P_{n,h,i,t}^k$ denotes the individual knowledge of the lot-sizing disruption problem.

$$Q_{it} = \begin{cases} 0 & Y_{it} = 0 \\ \sum_{m=t}^{t_1} d_{it}^1 & Y_{it} = 1 \end{cases} \quad i = 1, 2, \ldots, I;\ t = T_0 + 1, \ldots, T \tag{45.11}$$

for:

if $t = T$, $t_1 = T$, otherwise, t_1 can be acquired by (45.12), d_{it}^1 can be acquired by (45.13) and (45.14).

$$t_1 = \begin{cases} \min\{p - 1 \mid Y_{ip} = 1\} & \exists\ Y_{ip} = 1 \\ T & \forall Y_{ip} = 0 \end{cases} \quad t < T,\ \ p = t + 1, \ldots, T \tag{45.12}$$

$$I_i^t = \begin{cases} 0 & I_i^{t-1} < d_{it} \\ I_i^{t-1} - d_{it} & I_i^{t-1} \geq d_{it} \end{cases} \quad i = 1, 2, \ldots, I;\ \ t = T_0 + 1, \ldots, T \tag{45.13}$$

$$d_{it}^1 = \begin{cases} 0 & I_i^{t-1} \geq d_{it} \\ d_{it} - I_i^{t-1} & I_i^{t-1} < d_{it} \end{cases} \quad i = 1, 2, \ldots, I;\ \ t = T_0 + 1, \ldots, T \tag{45.14}$$

$$I_{it} = \sum_{m=1}^{T_0} Q_{im}^0 + \sum_{m=T_0+1}^{t} Q_{im} - \sum_{m=1}^{t} d_{im} \qquad i = 1, 2, \ldots, I;\ \ t = T_0 + 1, \ldots, T \tag{45.15}$$

$$K_{it} = \begin{cases} 0 & Q_{it} = Q_{it}^0 \\ 1 & else \end{cases} \quad i = 1, 2, \ldots, I;\ \ t = T_0 + 1, \ldots, T \tag{45.16}$$

45.3.2 The Algorithmic Flow

The flow of the knowledge evolution algorithm for the single level capacitated dynamic lot-sizing problem with the customer demand changing is as follows:

Step 1: initialize parameters

Initialize the number of the group space, group space scale, and the cognitive parameters c_1, c_2, c_3 and c_4, and set $k = 0$.

Step 2: initialize individual knowledge

The knowledge of individuals in each group space is initialized by (45.17).

$$p^k_{n,h,i,t} = 0.5 \\ n = 1,2,\ldots,N;\ \ h = 1,2,\ldots,H_n;\ \ i = 1,2,\ldots,I;\ \ t = T_0 + 1,\ldots,T \tag{45.17}$$

Step 3: the select operate

The lot-sizing problem hypothesis of each individual is acquired by (45.18). The $R(0,1)$ is a random value from 0 to 1.

$$x^k_{n,h,i,t} = \begin{cases} 1 & R(0,1) > p^k_{n,h,i,t} \\ 0 & else \end{cases} \\ n = 1,2,\ldots,N;\ \ h = 1,2,\ldots,H_n;\ \ i = 1,2,\ldots,I;\ \ t = T_0 + 1,\ldots,T \tag{45.18}$$

Step 4: compute the fitness value

In this paper, the two objective functions of the disruption management model are processed by the weighted sum method, and the resource constraints are processed by the penalty method. The fitness value of each hypothesis is computed by (45.19). α, β, γ and δ are weight coefficients, and M is a very big positive number.

$$\begin{aligned} f\left(X^k_{n,h}\right) = {} & \gamma\left(\sum_{i=1}^{I}\sum_{t=T_0+1}^{T} \alpha K_{it} + \sum_{i=1}^{I}\sum_{t=T_0+1}^{T} \beta\left|Q_{it} - Q^0_{it}\right|\right) \\ & + \delta\left(\sum_{i=1}^{I}\sum_{t=T_0+1}^{T} \left(P_{it}Q_{it} + S_{it}x^k_{nhit} + H_{it}I_{it}\right)\right) \\ & + M\sum_{j=1}^{I}\sum_{t=T_0+1}^{T}\left(\max\left\{0, \sum_{i=1}^{I}\left(a_{ij}x^k_{nhit} + b_{ij}Q_{it}\right) - C_{jt}\right\}\right) \end{aligned} \tag{45.19}$$

Step 5: the guess operate

$PB^k_{n,h}$ is defined as the individual experience, and GB^k_n is defined as the group experience. If $k = 0$, $PB^k_{n,h} = X^k_{n,h}$, otherwise, $PB^k_{n,h}$ can be acquired by (45.20). GB^k_n can be acquired by (45.21).

$$PB^k_{n,h} = \begin{cases} PB^{k-1}_{n,h} & f\left(X^k_{n,h}\right) > f\left(PB^{k-1}_{n,h}\right) \\ X^k_{n,h} & else \end{cases} \quad n = 1,2,\ldots,N;\ \ h = 1,2,\ldots,H_n \tag{45.20}$$

$$GB^k_n = \min\left(PB^k_{n,h}\right) \qquad n = 1,2,\ldots,N \tag{45.21}$$

Step 6: the refute operate

Compute the degree of truth by (45.22) to form social knowledge.

$$z^k_{i,t} = \sum_{n=1}^{N} gb^k_{n,i,t}/N \qquad i = 1,2,\ldots,I;\ \ t = T_0 + 1,\ldots,T \tag{45.22}$$

Step 7: update the individual knowledge

The individual knowledge is updated by (45.23) and (45.24). And then judge whether meet the termination condition or not. If meet the termination condition, terminate and output the result, otherwise, set $k = k + 1$ and go to step 3.

$$p^{k+1}_{n,h,i,t} = 0.5 + c_1\left(p^k_{n,h,i,t} - 0.5\right) + c_2\left(0.5 - pb^k_{n,h,i,t}\right) + c_3\left(0.5 - gb^k_{n,i,t}\right) + c_4\left(0.5 - z^k_{i,t}\right) \tag{45.23}$$

$$g\left(p^{k+1}_{n,h,i,t}\right) = \begin{cases} 1 & 1 \le p^{k+1}_{n,h,i,t} \\ p^{k+1}_{n,h,i,t} & 0 < p^{k+1}_{n,h,i,t} < 1 \\ 0 & p^{k+1}_{n,h,i,t} \le 0 \end{cases} \tag{45.24}$$

45.4 Simulation Experiments

In order to illustrate the availability of the model and algorithm, the knowledge evolution algorithm presented for the disruption management model is coded in Matlab R2010a. In this paper, the knowledge evolution algorithm has 10 group space, the scale of each group space is 15, $c_1 = 0.8$, $c_2 = c_3 = 0.05$, $c_4 = 0.095$, and the iterative number is 200 (Table 45.1).

The simulation instance in this paper is from literatures (Ma et al. 2005; Tang et al. 1997), which is a lot-sizing problem with five items, five periods and two resource constraints. The specific parameters of the simulation instance are shown

Table 45.1 The definition of the model symbols

N	The number of items
T	The length of the planning period
T_0	The moment of disturbance occurs
R	The number of available resources
Q^0_{it}	The original production quantity for item i in period t
M	A very big positive number
Q_{it}	The new production quantity for item i in period t
C_{jt}	Available time of resource j in period t
K_{it}	Change time of item i in period t
a_{ij}	Preparing time for item i on resource j
b_{ij}	Processing time per item i on resource j
Y_{it}	Production setup variable for item i in period t
I_{it}	Inventory for item i in the end of period t
P_{it}	Production cost per item i in period t
H_{it}	Holding cost per item i from period t to t+1
S_{it}	Setup cost for item i in period t
d_{it}	New demand for item i in period t

Table 45.2 The original model parameters

Item	Demand					Production cost					Inventory cost					Setup cost				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	12	11	18	16	10	3	3	4	5	5	1	2	1	1	2	20	35	30	35	20
2	13	11	18	10	10	4	4	5	3	3	1	3	1	2	2	16	30	16	23	30
3	12	11	18	16	12	3	3	4	5	5	3	1	3	2	2	19	20	13	20	23
4	12	11	14	13	12	3	3	4	5	5	2	1	1	1	2	24	31	25	24	30
5	12	11	18	13	12	3	3	4	5	5	3	3	1	1	1	19	24	25	27	28

Table 45.3 Time factor and capacity

Resource	Setup time					Production time					Capacity				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	10	23	24	25	26	2	1	5	1	3	666	600	550	350	480
2	9	6	10	28	26	1	2	3	4	2	666	600	550	350	480

in Tables 45.2 and 45.3. First write a program for the original lot-sizing problem, and the result is shown in Table 45.4.

Take the following disruption instances as research objects.

Disruption 1: The disruption is that the demand of item four in period two increases sixty units, and it occurs in period one.

Disruption 2: The disruption is that the demand of item two in period four decreases ten units and it occurs in period two.

Apply the above designed method to dispose the disruptions. Meanwhile, in order to demonstrate the feasibility and effectiveness of the proposed model, the re-scheduling method is applied to solve these two disruption instances, and the degree of deviation is calculated according to (45.1). A comparison of the results is shown in Table 45.5.

As can be seen from Table 45.5, the method of disruption management can take the minimum cost into consideration while reducing the deviation from the original plan effectively.

Table 45.4 The original optimal plan

Item	Lot-sizing				
	1	2	3	4	5
1	23	0	44	0	0
2	24	0	18	20	0
3	12	29	0	16	12
4	12	50	0	0	0
5	12	11	43	0	0
Total cost	1700				

Table 45.5 A comparison of the results of disruption management and re-scheduling

Item	The result of disruption 1										The result of disruption 2									
	Disruption management					Re-scheduling					Disruption management					Re-scheduling				
	Lot-sizing					Lot-sizing					Lot-sizing					Lot-sizing				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	23	0	44	0	0	23	0	44	0	0	23	0	44	0	0	23	0	44	0	0
2	24	0	18	20	0	24	0	18	20	0	24	0	18	10	0	24	0	18	0	10
3	12	29	0	16	12	12	11	18	16	12	12	29	0	16	12	12	29	0	16	12
4	12	98	0	0	12	12	110	0	0	0	12	50	0	0	0	12	50	0	0	0
5	12	11	43	0	0	12	11	43	0	0	12	11	43	0	0	12	11	43	0	0
Deviation times	2					3					1					2				
Deviation quantities	60					96					10					30				
Total cost	1898					1893					1670					1657				

45.5 Conclusion

During the process of production, the customer demand changing always leads to the infeasibility of the initial schedule. To solve this problem, the disruption management method was presented, and the disruption recovery model was constructed. Then the knowledge evolution algorithm was designed to solve this model in the paper. By contrast with the re-scheduling method, it showed that the disruption management method could reduce the deviation from the original plan and minimize the total cost, which demonstrated the feasibility and validity of the disruption management model.

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Chapter 46
Joint Production Planning and Recycle Pricing for a Hybrid Manufacturing and Remanufacturing System

Jian-mai Shi, Zhong Liu, Guo-qing Zhang and Cheng Zhu

Abstract The joint production planning and used product acquisition pricing problem is studied for a hybrid manufacturing and remanufacturing system. It is assumed that the return quantity of used products nonlinearly increases as their acquisition price increases, and the proportion of returned products which can be recovered into new product is stochastic and assumed to follow a know distribution. The remanufactured product can perfectly substitute the newly produced product, and both of them can be used to fulfill the market demand which is also uncertain. The objective is to maximize the overall profit of the hybrid system through simultaneously optimizing the decisions for pricing the used product and planning the production quantities of newly produced products and remanufactured products. An extended newsvendor model is developed to formulate the production planning and pricing problem, and its properties are analyzed. A numerical example is reported.

Keywords Closed loop supply chain · Hybrid manufacturing and remanufacturing system · Recycle · Reverse logistics · Uncertain return

46.1 Introduction

Closed loop supply chain (CLSC) has gained considerable attention from both practitioners and researchers in recent years. The main motivations for CLSC include the increasing awareness on environment, the government legislations, the

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customers' preference on environment-friendly products and the profitability of product recovery. It has been proven that remanufacturing can bring additional profit in many industries, which attract more and more original equipment manufacturers (OEMs) to take part in used product recovery businesses (Shi et al. 2011a).

Usually, OEMs control more knowledge about the product and market, which can help them more sufficiently utilize the used product and coordinate the supplying for newly produced products and remanufactured products. But integrating the remanufacturing activities into the normal manufacturing system also brings many new challenges to the OEM, such as the uncertainties on used product return, the coordination between uncertain demand and return (Guide 2000).

In CLSC, the recovery forms for used products usually include recycling, remanufacturing, refurbishing, repair, and direct reuse (Akçali and Çetinkaya 2011). In this study, a hybrid manufacturing and remanufacturing system is investigated, which is operated by an OEM. In the system, there are two channels to satisfy customer demand: one is to directly manufacture new products, while the other one is to remanufacture recycled products into new products. It is assumed that remanufactured products can perfectly substitute newly produced products. Thus, this is a typical hybrid manufacturing/remanufacturing system (Shi et al. 2011a). In the used product remanufacturing process, the OEM first acquires used products from customers, then remanufactured into as-new products. The obtained quantity of used products from customers is usually impacted by their acquisition price (Shi et al. 2010; 2011a, b). Therefore, the OEM has to make decisions in two types: the decisions related with remanufacturing which include the pricing for used products and their remanufacturing quantity, and the decision related with manufacturing which includes the quantity of new produced products. In this paper, the OEM's overall profit is to maximized though coordinately optimizing these decisions.

Our main contribution is to investigate the influence of quality uncertainty of used products on the hybrid manufacturing and remanufacturing system. The quality of used products is highly uncertain, and OEMs engaged in remanufacturing have to take complete inspection of used products to collect the ones that can be remanufactured into new products. But 100 % inspection of the used products is cost-inefficient and time-consuming. Therefore, there is a tendency in industry to evaluate the quality of used products though check the data provided by electronic devices (Zikopoulos and Tagaras 2008). In this way the information of the quality can be obtained quickly with lower cost. Although these methods are not fully accurate, they can present a better estimation for the quality of used products. Based on this observation, we assume that the remanufacturable rate of used product is uncertain, but its distribution can be known by some quick inspection method. As far as we know, it is the first investigation that incorporates the consideration of the quality uncertainty of used products into the hybrid production planning problem for closed loop supply chain.

The outlines of the paper are as follows. Section 46.2 presents an overview for related literatures. The optimization model is proposed in Sect. 46.3, and some properties of model are analyzed in Sect. 46.4. Section 46.5 presents a numerical example. In Sect. 6, We conclude the paper.

46.2 Literature Review

There is a stream of literature focusing on the optimization of CLSC, and various analytical and quantitative approaches are proposed (Akçali and Çetinkaya 2011; Pokharel and Mutha 2009; Guide and Van Wassenhove 2009). Here we present a review for the quantitative works related with the research on production/inventory planning and used product pricing.

In CLSC, when used products are acquired from customers and remanufactured into new products, the uncertainties in quality, quantity of used product return bring many challenges to the optimization of CLSC. Ferrer (2003) investigated the influence of uncertain recovery rate of used products on the remanufacturing lot sizing problem, but in the study the pricing decision of used products are not considered. Zikopoulos and Tagaras (2008) studied the economic attractiveness of sorting procedures for evaluating the quality of used products through a two-level CLSC. It is assumed that the distribution of the proportion of remanufacturable returns can be obtained by some simple sorting procedures. The influence of quality uncertainty of used product returns is further studied for a closed loop system formed by two recycle sites and one remanufacturing site in Zikopoulos and Tagaras (2007). Bakal and Akcali (2006) investigated the impacts of stochastic recovery rate on the acquisition of used products and remanufactured products, where the quality of used products is stochastic and impacted by the acquisition price. The impact of quality uncertainty on remanufacturing is also studied by Van Wassenhove and Zikopoulos (2010) and Teunter and Flapper (2011). From the above analysis, we can know that it is reasonable to assume the remanufacturable rate of used product return follow a known distribution when investigating the influence of uncertainty from the quality of used products.

There are also various works focusing on the uncertainty of the return quantity of used products. Fleischmann et al. (2002) presented a deep analysis of the inventory management problem for a reverse system. In Rubio and Corominas (2008), a reverse logistics system is studied in a lean production environment, and the capacity transfer problem is investigated between manufacturing and remanufacturing facilities. In Choi et al. (2007), an extended EOQ model is developed for an hybrid system, in which the market demand can be covered by remanufactured products and new products. In Shi et al. (2010 and 2011a), the multi-product production planning problem is studied for a hybrid manufacturing/remanufacturing system, and the influence of used product pricing is analyzed for the flexible production condition and the rigid production condition respectively. Shi et al. (2011b) further investigated the production and pricing problem for a similar system, in which the OEM should simultaneously optimize the prices for both used products and new products in uncertain environment.

From current literatures, we can see that it is a commonly accepted assumption to assume that the remanufacturable proportion of used products is uncertain and follows a known distribution. It is also recognized that the recycle quantity of used products is impacted by their acquisition price. Different models are presented to describe the relationship between the obtained quantity of used products and their acquisition price, such as linear model (Shi et al. 2011a, b; Bakal and Akcali 2006), nonlinear model (Shi et al. 2010). But there are few literatures that investigate the influence of these two aspects on the hybrid manufacturing/remanufacturing system.

46.3 Model Formulation

46.3.1 Framework of the System

In the studied system, the OEM can satisfy downward demand by two production channels: one is to produce new products in the manufacturing facility, and the other one is to remanufacture used products into new products in the remanufacturing facility. The system framework is shown in Fig. 46.1. In the reverse flow, the OEM determines the acquisition price for used products and acquires them from customers, then stocks the obtained used products in the recoverable inventory. Used products are remanufactured into new products in the remanufacturing facility. The quality of used products is stochastic and the exact quality can only be known after they are disassembled and tested. The quantity of products remanufactured from used products usually is not enough to cover all the market demand. Thus, the OEM should also manufacture some additional new products in the manufacturing facility. All these products are held in the serviceable inventory, which are used to cover the market demand.

The objective of this study is to maximize the overall profit of the hybrid system through simultaneously optimizing the decisions for pricing the used product and planning the production quantities of newly produced products and remanufactured products.

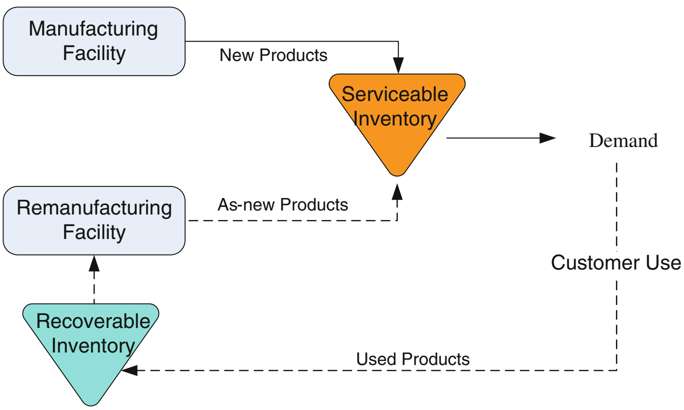

Fig. 46.1 Framework of the hybrid manufacturing/remanufacturing system

We first propose some assumptions for the problem to facilitate the development of the model.

- The product remanufactured from the used product has no distinction with the newly manufactured product.
- The demand for new products is random and follows a known distribution.
- The amount of used products obtained from customers is determined by their acquisition price, which is $R(h) = ah^b$ ($a \geq 0$ and $b < 1$), where h is the price for acquiring the used products.
- The quality of the used products is stochastic. The percentage of used product returns that can be remanufactured into new products is stochastic.
- The quantity of used products obtained from customers has no relationship with the market demand.

46.3.2 Mathematical Model

All the notations used to develop the model is presented below.

Parameters:

p = the price for selling one unit of new product
g = the punishing cost for each unsatisfied demand
s = the punishing cost for each unsold new product
c = the cost for producing each new product
c_s = the unit cost for salvaging used products that are unremanufacturable
c_r = the cost for remanufacturing each used product, which is assumed to be less than c
c_e = the cost in the emergent order for producing each new product
$F^d(\cdot)$ = cdf of the demand distribution
$f^d(\cdot)$ = pdf of the demand distribution
μ^d = mean of the market demand for new products
σ^d = standard deviation of the market demand for new products
$F^r(\cdot)$ = cdf of the distribution for v.
$f^r(\cdot)$ = pdf of the distribution for v, and v is a stochastic variable that denotes the percentage of unremanufacturable used products
σ^r = standard deviation of v.
μ^r = mean of v

Variables:

X^p = the planning quantity for producing new products.
h = the price for acquiring used products.
X^r = the planning quantity for remanufacturing used product.
Q = the overall supplying quantity for all new products.

The obtained quantity of used products is determined by their acquisition price, that is, $R(h) = ah^b$, while the planning quantity for remanufacturing used products, X^r, should be determined by both their quantity and quality. When the practical unremanufacturable amount of used products is less than X^r, the OEM must propose an emergent call for manufacturing some additional new products, which generates a cost of c_e for each product. Because the emergent call is not included in the production plan, c_e is usually more than c. The used products that can not remanufactured into new products are salvaged, which can generate some revenue, c_s. When the practical unremanufacturable amount of used products is more than X^r, the OEM would salvage all the used products that overtop the planning. Thus, the overall cost for used products remanufacturing is as follows.

$$RC(X^r, h) = \begin{cases} c_r R(h)v + c_e[X^r - R(h)v] \\ \quad - c_s R(h)(1-v), & R(h)v \le X^r, \\ c_r X^r - c_s[R(h) - X^r], & R(h)v \ge X^r. \end{cases}$$

Let $z = X^r/R(h)$, then

$$RC(z, h) = \begin{cases} R(h)[c_r v + c_e(z - v) - c_s(1 - v)], & v \le z, \\ R(h)[c_r z - c_s(1 - z)], & v \ge z. \end{cases}$$

Then the overall expected cost for used products remanufacturing is

$$RC(z, h) = ah^b \left\{ \begin{array}{l} \int_0^z [c_r v + c_e(z - v) - c_s(1 - v)] f^r(v) dv \\ + \int_z^1 [c_r z - c_s(1 - z)] f^r(v) dv \end{array} \right\}.$$

Therefore, we can obtain the following optimization model for the joint production planning and recycle pricing problem.

Max

$$\begin{aligned} \Pi = & \int_0^Q [pu - s(Q - u)] f^d(u) du \\ & + \int_Q^\infty [pQ - g(u - Q)] f^d(u) du \\ & - ah^b \left\{ \begin{array}{l} \int_0^z [c_r v + c_e(z - v) - c_s(1 - v)] f^r(v) dv \\ + \int_z^1 [c_r z - c_s(1 - z)] f^r(v) dv \end{array} \right\} \\ & - cX^p - ah^{b+1} \end{aligned} \tag{46.1}$$

subject to

$$X^r = ah^b z, \tag{46.2}$$

$$Q = X^p + X^r, \tag{46.3}$$

$$X^r \geq 0, h \geq 0, Q \geq 0, X^p \geq 0, z \geq 0. \tag{46.4}$$

In Function (46.1), the first term calculates the expected profit when the practical demand is less than the overall supplying quantity, while the second term calculates the expected profit when the practical demand is more than the overall supplying quantity. The third term is the expected cost for remanufacturing all used products, and the fourth term is the cost for newly produced products. The last term is the cost for acquiring all used products.

Constraint (46.2) proposes the relationship between X^r and z. Constraint (46.3) ensures the overall supplying quantity be the sum of production quantities for newly manufacturing products and remanufactured products. Constraints (46.4) restrict all variables are no less than zero.

When we substituting (46.2) and (46.3) into Function (46.1), the model is transformed into a more convenient form, which is

Max

$$\begin{aligned}\Pi = & \int_0^Q [pu - s(Q-u)]f^d(u)du \\ & + \int_Q^{\infty} [pQ - g(u-Q)]f^d(u)du - cQ \\ & - ah^b \left\{ \begin{aligned} & \int_0^z [c_r v + c_e(z-v) - c_s(1-v)]f^r(v)dv \\ & + \int_z^1 [c_r z - c_s(1-z)]f^r(v)dv \end{aligned} \right\} \\ & - ah^{b+1} + ah^b cz \end{aligned} \tag{46.5}$$

subject to

$$Q - ah^b z \geq 0, \tag{46.6}$$

$$Q \geq 0, h \geq 0, z \geq 0. \tag{46.7}$$

46.4 Properties of the Model

The properties of the model are studied, based on which a solution approach for the problem can be developed.

Proposition 1 *The optimal solution to maximize function Π is*

$$Q^{*} = F^{d-1}\left(\frac{p+g-c}{p+g+s}\right),$$

$$z^{*} = F^{r-1}\left(\frac{c-c_r-c_s}{c_e-c_r-c_s}\right), h^{*} = \frac{b\theta(z^{*})}{b+1}.$$

Proof of Proposition 1

$$\partial\Pi/\partial Q = (p+g-c) - (p+g+s)F^{d}(Q),$$

$$\partial\Pi/\partial h = abh^{b-1}\theta(z) - a(b+1)h^{b},$$

and

$$\partial\Pi/\partial z = ah^{b}[(c-c_r-c_s) - (c_e-c_r-c_s)\,F^{r}(z)],$$

where

$$\theta(z) = cz - \int_{z}^{1}[c_r z - c_s(1-z)]f^{r}(v)dv - \int_{0}^{z}[c_r v + c_e(z-v) - c_s(1-v)]f^{r}(v)dv.$$

There is only one root for $\partial\Pi/\partial Q = \partial\Pi/\partial p^{r} = \partial\Pi/\partial z = 0$, which is as follows

$$Q^{*} = F^{d-1}\left(\frac{p+g-c}{p+g+s}\right),$$

$$z^{*} = F^{r-1}\left(\frac{c-c_r-c_s}{c_e-c_r-c_s}\right), h^{*} = \frac{b\theta(z^{*})}{b+1}.$$

46.5 Numerical Example

A numerical example is proposed to illustrate the model and the hybrid manufacturing/remanufacturing system. The demand for new products follows normal distribution, while the percentage of used product that can be remanufactured into new products is also assumed to follow normal distribution. Table 46.1 shows the value of all parameters.

Table 46.1 Parameters of the example

p	c	g	s	μ^{d}	σ^{d}	a
189	107.65	58.10	39.05	2000	600	400
b	μ^{r}	σ^{r}	c_r	c_s	c_e	
0.35	0.75	0.05	25.45	7.25	118.45	

The problem is solved and the optimal solution is $Q^* = 1\ 981$, $X^{p*} = 1\ 125$, $X^{r*} = 856$, $h^* = 16.22$. The optimal expected profit of the OEM is 143455.99.

46.6 Conclusion

This paper studies the production planning and used product acquisition integrated problem for a representative manufacturing and remanufacturing system. We assume the amount of used products nonlinearly increases with their acquisition price, while their remanufacturable percentage is random. The product remanufactured from the used product is assumed to have no distinction with the newly manufactured product. The market demand for new products is also random, and can be covered by both remanufactured products and new products. The objective is to maximize the overall profit of the hybrid system through simultaneously optimizing the decisions for pricing the used product and planning the production quantities of newly produced products and remanufactured products. An optimization model is developed, and the properties of model are analyzed.

This paper only investigates the optimization for the single product problem. In practical business, the OEM often has to optimize the production planning and pricing decisions under limited manufacturing and remanufacturing capacities in the closed loop system. Thus, a meaningful extension is to investigate the multi-product problem, subject to production resource constraints.

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Chapter 47
Key Performance Indicator for ERP Developed in the Solar Cell Industry

Ming-Lang Wang and K. W. Wang

Abstract The Enterprise Resource Planning (ERP) appreciated by enterprises recently is one system evolving from Material Requirement Planning (MRP) and MRPΠ or revised based on MRP and MRPΠ. ERP introduced into and integrated with a company's internal system drives computerization and automation of the whole enterprise and supports the enterprise to combine five major modules including production module, marketing module, human resource module, R&D module, and financial accounting module with resource planning. The ERP system which reflects any real-time messages, distributes resources to demanders, and offers references of policy-making to enhance an enterprise's competitiveness is one integral IT system with different modes matching an enterprise's specific operation style.

Keywords Solar cell industry · Enterprise resource planning (ERP) · Key performance indicator (KPI)

47.1 Introduction

Most researches in terms of Enterprise Resource Planning (ERP) made by scholars at home and abroad preferred the issue of satisfaction at performance of ERP (Ho et al. 2003) or results analysis (Pearson 1901) after introduction of ERP rather than discussions of Key Performance Indicator (KPI) for ERP. In this study, the key performance indicators associated with combination of the ERP system and the solar cell industry were investigated via questionnaire survey.

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Based on the above mentioned research backgrounds and motives, this sturdy is intended for realizing the following purposes:(1) Investigate correlations among Enterprise Resource Planning (ERP), Key Performance Indicators (KPI), and the solar cell industry; (2) Investigate effects out of Enterprise Resource Planning (ERP) by finding key performance; (3) Employ statistical tests such as factor analysis to verify correlations between indicators and understand realistic status of an enterprise to which ERP was introduced.

47.2 Literature Review

47.2.1 Enterprise Resource Planning

With reference to the dictionary published by the famous American Production and Inventory Control Society (APICS; renamed as the Resource Management and Education Association recently) which initiated MRP & MRPII, the definition of "Enterprise Resource Planning (ERP)" is: "An accounting-oriented IT system which is used in verifying and planning a whole enterprise's resources necessary for reception, manufacture, delivery and settlement in terms of customers' orders; the difference between an ERP system and a classic MRPII system consists in technical demands, for instance, graphic user interface, relational database, fourth generation language, computer-aided software for R&D, client/server architecture, and open system". The statement includes the following keynotes: (1) the ERP system is an accounting-oriented system; (2) the ERP system emphasizes and satisfies customers' demands; (3) the ERP system is used in planning an enterprise's all resources; (4) the ERP system employs mature IT in 1990s.

As one symbol to optimize integrations and applications of an enterprise's resources, an ERP system brings three types of effects to an organization: (1) Middle-to-high managers who depend on application systems and data integration between departments will collect inter-department real-time messages to effectively regulate a whole enterprise's operations; (2) The same database on the basis of integrated data is available in various subsystems and promotes smooth inter-department communication because of consistently defined data; (3) The productivity is promoted when mistakes out of repeated inputs are avoided.

47.2.2 Key Performance Indicator

The purposes of evaluating performance management indicators consist in indicating whether an organization's overall performance confronts to goals and integrating all information as a policy maker's references for distribution of resources and budgets. The criteria and content for performance appraisal will lead an organization's future actions or contribute to an enterprise's policy-making. As the most powerful or important indicators of one organization currently, Key Performance Indicator (KPI) is also one method for performance management to measure if an enterprise's competitive strategies are fulfilled (Hsu 2000, Lien et al. 2008). The features of KPI includes: (1) KPI depends on an organization's goals; (2) KPI is used to measure controllable performance; (3) KPI focuses on key business activities rather than all operating processes; (4) KPI should be acknowledged by all members in one organization (Wang 2004).

47.2.3 Solar Cell Industry Analysis

Taiwan lacking own energy resources and importing more than 97 % of them from foreign countries and particular fossil energy, which accounts for 88 % and indulges emissions of carbon dioxide, was short of diversified energy resources and auxiliary power to share peak loads. Accordingly, Taiwan had joined researches of solar cells since 1970s and made much of them in the recent decade. The upstream and downstream solar energy manufacturers' cost structures (shown in percentage) are: (1) photovoltaic system: cell module (50 %) and power regulator (25 %); (2) solar module: solar cell (70 %); (3) solar cell: chip (60 %). In the future decade, the global solar energy industry as the alternative energy industry will be an eye-catcher with high development potential because of the strong annual average growth rate, 20 %.

Having emerged since 2006, Taiwan's solar cell industry surpassed those of Japan and Germany in the period from 2009 to 2010 and was only second to China around the whole world. The total capacity of Taiwan and China (48 % of the global output) has accounted for 60 %. The sales volume of Taiwan's solar cell industry was NTD 253 billion 100 million in 2010 and will be 425 billion 700 million by 2013. Among all countries for manufacture of solar cells, Asian countries have produced three fourths of solar cells and Taiwan ranked fourth behind Japan by 0.3 % only in 2009. However, Taiwan's manufacturers as OEMs of Japan should rank third around all countries. As to the global market share, the solar cells accounting for 11 % due to significantly different development in the solar energy industry implies Taiwan's competitiveness in this industry is solar cells.

47.3 Methodology

47.3.1 Design of a Questionnaire

Depending on 5 ERP modules including production, marketing, human resource, R&D and financial affair for the solar cell industry, we developed 5–15 topics for

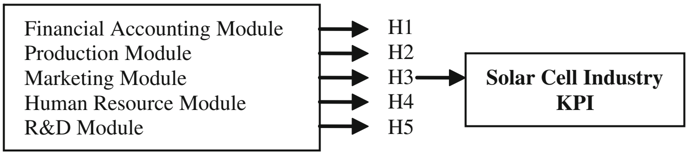

Fig. 47.1 Research structure

each module and incorporated the Likert Five Point Scale to become our questionnaire. With the questionnaire completely designed, 50 copies were given to a company's employee who was engaged in the solar energy industry and helped us to distribute them, 35 copies in Taiwan and 15 copies in China (via the company's salespersons) and finally 44 of 50 copies were collected (response rate = 88 %; α value = 0.964 (high reliability)). On the other hand, the reliabilities for five dimensions (production; marketing; human resource; R&D; financial affair) classified in the questionnaire are 0.822, 0.927, 0.874, 0.881 and 0.924, all of which were larger than 0.7 as the basis to complete a formal questionnaire without any topic deleted.

47.3.2 Research Structure

(1) H_1: The significant positive correlation exists between a financial accounting module incorporated in the ERP system by one manufacturer of the solar cell industry and the manufacturer's performance (Fig. 47.1)
(2) H_2: The significant positive correlation exists between a production module incorporated in the ERP system by one manufacturer of the solar cell industry and the manufacturer's performance
(3) H_3: The significant positive correlation exists between a marketing module incorporated in the ERP system by one manufacturer of the solar cell industry and the manufacturer's performance
(4) H_4: The significant positive correlation exists between a human resource module incorporated in the ERP system by one manufacturer of the solar cell industry and the manufacturer's performance
(5) H_5: The significant positive correlation exists between an R&D module incorporated in the ERP system by one manufacturer of the solar cell industry and the manufacturer's performance

47.4 Results

47.4.1 One-Way ANOVA

The major concerns of the company's executives who were grouped according to their levels were tested. The significant difference due to executives' levels is found in indicators such as "customer's satisfaction" and "improved after-sales service" ($\alpha = 0.05$) which were particularly stressed by higher-level administers, e.g., deputy managers, senior engineers and others (salespersons mostly) (Table 47.1).

The major concerns of the company's executives who were grouped according to their levels were tested. The significant difference due to executives' levels is found in indicators such as "enhanced supply chain management", "better on-time delivery", and "automated and transparent work site" ($\alpha = 0.05$) which were particularly stressed by higher-level administers, e.g., deputy managers, senior engineers and others (salespersons mostly) (Table 47.2).

Table 47.1 Marketing module

	Customer's satisfaction	Improved after-sales service	Sample size
Senior engineer	4.18	3.97	32
Associate manager	3.25	4.00	4
Deputy manager	4.40	3.40	5
Manager	3.00	2.75	4
Other	4.09	4.19	36
Total	4.05	3.96	81
Rank	4.00	7	
F Test	3.61	3.76	
Significance	0.01	0.00	

Table 47.2 Production module

	Better on-time delivery	Automated transparent work site	Enhanced supply chain management	Sample size
Senior engineer	4.12	4.15	4.26	32
Associate manager	3.75	3.75	4.00	4
Deputy manager	4.40	4.20	4.00	5
Manager	3.25	3.50	4.25	4
Other	4.16	4.00	4.16	36
Total	4.09	4.03	4.19	81
Rank	7	9	2	
F Test	2.99	4.50	3.02	
Significance	0.02	0.00	0 0.02	

Table 47.3 Human resource module

	Specialized IT capability and number of ERP	Person job fit	Person-group fit	Department's work efficiency	Sample size
Senior engineer	3.65	4.00	4.06	4.03	32
Associate manager	3.25	3.50	4.00	3.50	4
Deputy manager	4.00	4.20	4.00	3.60	5
Manager	2.50	2.75	2.75	3.75	4
Other	3.94	3.91	3.94	4.13	36
Total	3.70	3.88	3.93	3.99	81
Rank	10	9	8	2	
F Test	3.54	2.68	2.57	2.63	
Significance	0.01	0.03	0.03	0.03	

Table 47.4 R&D module

	Reduced lead time for R&D and time-to-market of products	Number of R&D engineers	Sample size
Senior engineer	4.06	4.06	32
Associate manager	3.75	3.75	4
Deputy manager	4.00	4.00	5
Manager	3.25	3.25	4
Other	4.13	3.81	36
Total	4.01	3.89	81
Rank	4	7	
F Test	4.11	4.09	
Significance	0.00	0.00	

The major concerns of the company's executives who were grouped according to their levels were tested. The significant difference due to executives' levels is found in indicators such as "department's work efficiency", "specialized IT capability and number of ERP certificates", "person-job fit", and "person-group fit" ($\alpha = 0.05$) which were particularly stressed by higher-level administers, e.g., deputy managers, senior engineers and others (salespersons mostly) (Table 47.3).

The major concerns of the company's executives who were grouped according to their levels were tested. The significant difference due to executives' levels is found in indicators such as "number of R&D engineers" and "reduced lead time for R&D and time-to-market of products" ($\alpha = 0.05$) which were particularly stressed by higher-level administers, e.g., senior engineers, deputy managers and others (salespersons mostly) (Table 47.4).

The major concerns of the company's executives who were grouped according to their levels were tested. The significant difference due to executives' levels is found in the indicator, "reduced transportation and distribution costs" ($\alpha = 0.05$),

Table 47.5 Financial accounting module

	Reduced transportation and distribution costs	Sample size
Senior engineer	4.03	32
Associate manager	3.50	4
Deputy manager	4.40	5
Manager	3.75	4
Other	3.91	36
Total	3.96	81
Rank	10	
F Test	2.62	
Significance	0.03	

which were particularly stressed by higher-level administers, e.g., deputy managers, senior engineers and associate managers (Table 47.5).

47.4.2 T Test

The major concerns of the subjects grouped into managers and non-managers were tested. The significant difference due to their job titles is found in indicators such as "customer's satisfaction" and "improved after-sales service" (Table 47.6).

The major concerns of the subjects grouped into managers and non-managers were tested. The significant difference due to their job titles is found in indicators such as "priority of purchase orders & order date", "promotion of productivity" and "integration of OS". These indicators with significant difference were more stressed by non-managers than managers thanks in part to these non-managers' positions, e.g., factory directors, who were concerned about all issues on production lines (Table 47.7).

Table 47.6 Marketing module

Topic	Non-Manager	Manager	All subjects	Rank	Significance (One-tail)	<0.05
Customer's satisfaction	4.14	3.64	4.05	5	0.01	*
Improved after-sales service	4.23	3.86	4.16	3	0.03	*

Table 47.7 Production module

Topic	Non-manager	Manager	All subjects	Rank	Significance (one-tail)	<0.05
Priority of purchase orders & order date	3.95	3.43	3.86	11	0.04	*
Promotion of productivity	4.14	3.71	4.06	8	0.03	*
Integration of OS	4.23	3.86	4.16	3	0.03	*

Table 8 Human resource module

Topic	Non-manager	Manager	All subjects	Rank	Significance (one-tail)	<0.05
Specialized IT capability and number of ERP certificates	3.79	3.29	3.70	10	0.01	*
Person-job fit	3.95	3.50	3.88	9	0.02	*
Employee's work efficiency	4.08	3.57	3.99	2	0.04	*

Table 47.9 R&D module

Topic	Non-manager	Manager	All subjects	Rank	Significance (one-tail)	<0.05
Individual satisfaction for a company's hardware	3.91	3.29	3.80	8	0.00	*
New R&D engineer's comprehension in work processes	4.08	3.21	3.93	6	0.00	*
R&D capability in special specification products	4.29	3.64	4.18	2	0.00	*

The major concerns of the subjects grouped into managers and non-managers were tested. The significant difference due to their job titles is found in indicators such as "specialized IT capability and number of ERP certificates", "person-job fit" and "employee's work efficiency". These indicators with significant difference were more stressed by non-managers who faced ordinary employees and realized their conditions than managers (Table 47.8).

The major concerns of the subjects grouped into managers and non-managers were tested. The significant difference due to their job titles is found in indicators such as "individual satisfaction for a company's hardware", "new R&D engineer's comprehension in work processes", and "R&D capability in special specification products". These indicators with significant difference were more stressed by non-managers than managers because these non-managers such as operators or salespersons who confronted customers' queries or demands for specifications expected to give answers based on more data from the company and satisfy customers but the managers (or higher-level administrators) who preferred charts in the output procedure emphasized the graphic management function of the ERP system (Table 47.9).

The major concerns of the subjects grouped into managers and non-managers were tested. The fact of no significant difference between managers and non-managers in the financial accounting module implies two types of subjects were concerned about the financial issue. In spite of this, some indicators with minor difference rather than significant difference between managers and non-managers were more stressed by non-managers than managers except other indicators such as "function of the ERP system for estimations of gross profits", "improved cash

Table 47.10 Financial accounting module

Topic	Non-manager	Manager	All subjects	Rank	Significance (one-tail)	<0.05
Function of the ERP system for estimations of gross profits	4.08	4.29	4.11	7	0.16	
Improved cash management	3.85	4.00	3.88	12	0.28	
Reduced labor cost	4.09	4.43	4.15	4	0.06	
Reduced material cost	3.94	4.00	3.95	11	0.40	
Reduced procurement cost	4.18	4.00	4.15	4	0.20	
Reduced transportation and distribution costs	4.23	4.14	4.21	2	0.35	
Reduced management cost	3.67	3.43	3.63	13	0.21	
Increased turnover rate between funds and inventories	3.97	3.93	3.96	10	0.42	
Increased return on sales	4.14	4.07	4.13	6	0.37	
Reduced maintenance cost of machines and computers	4.02	4.21	4.05	9	0.21	
Reduced inventory cost	4.23	4.00	4.19	3	0.13	
Reduced return rate	4.27	4.07	4.24	1	0.16	
Increased revenue and profit	4.14	4.07	4.13	6	0.37	

management", "reduced labor cost", and "reduced maintenance cost of machines and computers" because non-managers, e.g., salespersons or operators, who directly faced customers or machines had to take any immediate measures but managers preferred reducing a company's major costs (Table 47.10).

47.5 Conclusion

In this study for the ERP system introduced into the solar cell industry, the Key Performance Indicators (KPI) which were found and renamed in accordance with principal component analyses were taken as elements in one-way ANOVA and T test for obtaining ranks and summarizing significance. The recommendations for these five dimensions are shown as follows:

(1) The factors of the marketing module emphasized in the ERP system are: (1) function: "real-time confirmation of specifications and estimation of prices" and "integrated electronic and traditional written quotes" (dominant factor); (2) marketing: "customer's satisfaction" (dominant factor), "improved competitive position" and "method for product marketing"; (3) sale: "simplified order processing procedure" and "cash discount available for an annual purchase volume over a specific total amount" (dominant factor)

(2) The factors of the production module emphasized in the ERP system are: "accurate delivery time", "better on-time delivery", "integration of OS", "simplification of inefficient complicated processes", "enhanced supply chain

management", "compliance of a production process", and "correct product information" in which "better on-time delivery", "integration of OS", and "enhanced supply chain management" are dominant factors

(3) The factors of the human resource module emphasized in the ERP system are: (1) department: "employee's work performance", "person-department fit", "educational training for employees", "employee's work efficiency", "department's work efficiency", and "employee joining policy-making" in which "employee's work efficiency" and "department's work efficiency" are dominant factors; (2) individual: "employee's job satisfaction" as the dominant factor
(4) The factors of the R&D module emphasized in the ERP system are: (1) system: "contractor's technical skills", "reduced lead time for R&D and time-to-market of products", "R&D capability in special specification products", and "graphic management function" in which "R&D capability in special specification products" and "graphic management function" are dominant factors; (2) quality: "flexibility of system quality"
(5) The factors of the financial accounting module emphasized in the ERP system are: (1) procurement: "reduced material cost", "improved cash management", "increased revenue and profit", "increased return on sales", "reduced return rate", "function of the ERP system for estimations of gross profits", "reduced inventory cost", "increased turnover rate between funds and inventories", and "reduced procurement cost"; (2) cost: "reduced labor cost", "reduced management cost", "reduced maintenance cost of machines and computers", and "reduced transportation and distribution costs" which depend on realistic situations

It is recommended that other researchers can make further investigations for the following issues:

(1) The variance analysis is available in solar cell manufacturers with or without the ERP system
(2) The similar research method is applicable to another industry (e.g., semiconductor industry) to find any same or distinct conclusions
(3) The similar research method is applicable to enterprises adopting the ERP system in developed nations and developing nations to find any same or distinct conclusions

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Chapter 48
Lean Development: How to Reach Higher Effectiveness and Efficiency

Uwe Dombrowski, Isa von Hoesslin, David Ebentreich and Thimo Zahn

Abstract Over the past years many companies have introduced lean elements to optimize their production and assembly processes. As a result of the achievements of lean production systems the lean elements are also increasingly applied in product development (lean development). So far there is little known about how far the elements of lean development are spread as well as their influence on effectiveness and efficiency enhancement. This article will present the results of a study in which 60 mostly German companies of different sizes and from different industries took part. The study identified which elements of lean development were implemented in the development process and which delivered the greatest benefit to it.

Keywords Effectiveness · Efficiency · Lean development

48.1 Introduction

Due to changed conditions, manufacturing companies have dealt intensively with the implementation of lean production systems (LPS) over the past few years. A LPS is a company-specific, methodological set of regulations for the comprehensive and integrated design of the companies' processes (Dombrowski et al. 2005). Changed conditions not only influence production but also product development. Comparable sets of regulations for product development (lean development) to enhance effectiveness and efficiency as well as to improve employees' and the organization's abilities are more and more focused. Companies such as Toyota that have already implemented the lean philosophy into product

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development, generate innovative products and processes of higher quality in significant less time and with fewer resources (Morgan and Liker 2006). Companies following the example of Toyota find plenty of lean development concepts that differ from each other. Furthermore there is a lack of knowledge about the influence of the elements on effectiveness and efficiency enhancement. Therefore the Institute for Advanced Industrial Management, TU Braunschweig revealed in a study which elements of lean development are implemented in companies and which delivered the greatest benefit.

48.2 Methodology

Based on a literature review, 19 lean development elements were identified (Morgan and Liker 2006; Ballé and Ballé 2005; Sehested and Sonnenberg 2011; Ward 2007). This paper uses an industry survey as research method. In a web-based survey the elements were examined towards their distribution with closed questions and their influences on effectiveness and efficiency by a four-stage Likert scale. In this case effectiveness means "developing the right products", e.g. innovative products, low lifecycle costs and high customer satisfaction. The meaning of efficiency is "developing the product right", e.g. low costs, short time-to-market and few changes. In the following the participants of the survey will be introduced before the essential results will be presented.

The majority of the 60 companies is located in the automotive industry (27 %) as well as machinery and plant engineering (22 %) followed by electronic (11 %) and consumer goods industry (7 %). Figure 48.1 shows the annual sales of the

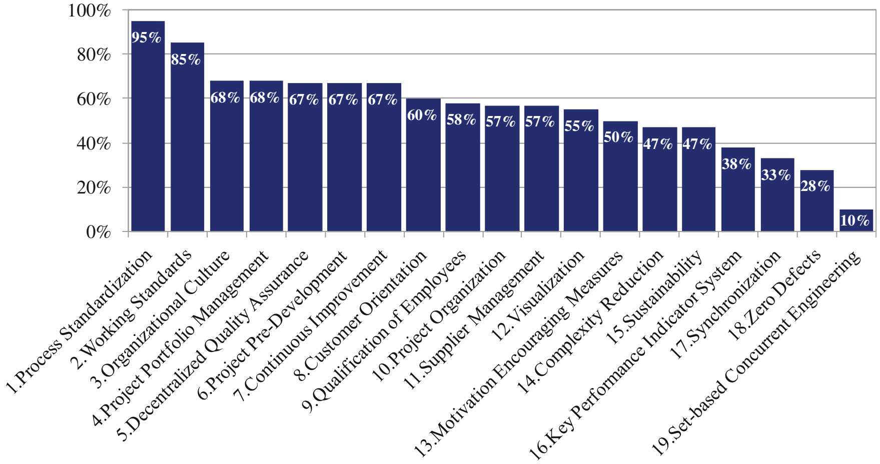

Fig. 48.1 Overview of the diffusion rate of lean development elements

Table 48.1 Annual turnover and number of employees in product development

	Number of employees					
Annual turnover [€]	1–50	50–100	100–500	500–1000	>1000	Sum
<50 m	6	0	0	0	0	6
50–500 m	11	5	3	0	0	19
500 m−1 bn	1	4	3	0	0	8
1–10 bn	3	2	6	2	2	15
10–50 bn	1	1	3	1	3	9
>50 bn	0	0	2	1	0	3
Sum	22	12	17	4	5	60

companies and the number of employees in product development. Moreover it shows that 37 % of the companies have less than 50 employees working in product development (Table 48.1).

48.3 Results

48.3.1 Diffusion Rate of Lean Development Elements

After introducing the group of participants, in the following section the partial results of the study are presented.

1. **Process standardization** involves standardized workflows with defined responsibilities, documents and work instructions within the development process (Morgan and Liker 2006). Standardization supports the reduction of errors, the minimization of variability, the increase of efficiency and the creation of a basis for continuous improvement (Ballé and Ballé 2005; Brown 2007; Schuh et al. 2008). Within the number of participants 95 % already adopt process standardization.
2. **Working standards** are specifications that contain the sequence of work steps, time for an element, cycle time and quantities of inventory (Rother 2010). Working standards increase employee's performances as well as the willingness to perform. Moreover it simplifies measures for employee qualification. Disciplinary (e.g. Methods of Construction, Design of Experiments) and interdisciplinary (e.g. Risk Analysis, Product Life Cycle Calculation) working standards were implemented in 85 % of the companies (Morgan and Liker 2006; Rother 2010)
3. 68 % of the companies started to implement an **organizational culture** of no-blame and problem-solving. This approach is based on openly handling problems and errors. Reasons for problems are assumed in the process. Therefore the focus problem solving shifts from person to process (Rother 2010; Mann 2006).

4. **Project Portfolio Management (PPM**) is an approach that fosters efficiency in the innovation process. On the basis of strategic, technical, economic and organizational criteria as well as objective methods product development projects are evaluated, selected and prioritized. Thereby it supports the selection and initiation of the right projects (Sehested and Sonnenberg 2011). A large number of interviewed companies (68 %) established PPM.
5. **Decentralized quality assurance** contains the analysis, validation and optimization of product and process quality. Methods of the decentralized quality assurance (e.g. Rapid Prototyping, Cardboard Engineering, Checklists, Customer–Supplier Relationship) were implemented by 67 % of the companies (Wiendahl 2008).
6. Compared to the conventional product design **project pre-development** serves to specify product concepts at the beginning of the product design (e.g. Technology, Functionality, Carry-Over-Part, Product Vision, Modularization, Production Concept, Target Costs) (Clark 1989). The majority (67 %) of the companies uses this element.
7. **Continuous improvement** means the simultaneous and day-to-day optimization of processes. There is an unlimited capability for improvements within the processes of a company. The majority of the interviewed companies (67 %) are using continuous improvement in product development (Morgan and Liker 2006; Rother 2010).
8. Requirements engineering identifies, evaluates and prioritizes internal and external product requirements. The intention is to maximize the customer value and to minimize the product and process complexity. Over half of the interviewed companies (60 %) implemented central requirements engineering. Thus the **customer orientation** increases by handling positive as well as negative feedback of internal and external customers (Hull et al. 2011).
9. **Qualification of employees** describes a continuous learning process. It has to match the long-term corporate philosophy and has to be standardized to enable a high as well as homogeneous proficiency level. These specific requirements of lean development are considered in 58 % of the companies by a qualification of employees (Morgan and Liker 2006; Liker 2004).
10. Most of the companies (58 %) adopt a **project organization** in the product development process, where Chief Engineers and Module Development Teams are integrated. The Chief Engineer serves as the voice of the customer. His role is to plan, solve conflicts, support, communicate, monitor and decide. Module Development Teams are independent, interdisciplinary and support the development process among other things by product and process benchmarking (Morgan and Liker 2006; Ward 2007; Liker 2004).
11. **Supplier Management** is an approach for companies to govern the relationship with their suppliers systematically. 57 % of the companies practice a supplier management that considers special requirements of the product development (e.g. Innovative Ability, Personnel Exchange, Communication, Protection of Intellectual Property) (Morgan and Liker 2006).

12. **Visualization** describes the graphical representation of objectives, key performance indicators, problems as well as information about work flow and work results. It facilitates the identification and solution of problem areas and increases the responsiveness (Morgan and Liker 2006; Mascitelli 2011). Fifty-four percent of the companies adopted this element in the product development.
13. The lean element motivation contains different methods to increase the willingness to perform of the employees. The drivers are the corporate image, the attractiveness of work (e.g. Personal Responsibility, Challenges), work environment (e.g. Organizational Structure, Leadership), work-life-balance, career opportunities (e.g. Training Possibilities) and financial incentives (Liker 2004). Half of the number of participants (50 %) is using **motivation encouraging measures**, which consider the requirements of product development.
14. Complexity affects the attainment of quality, cost, time, flexibility, effectiveness as well as efficiency objectives. Among other things the abandonment of a complexity management is the identification, analysis as well as review of complexity driver with the aim to identify an appropriate measure for **complexity reduction** (Schuh 2005). Less than half of the companies (47 %) use the reduction of complexity in the product development process (e.g. Assortment Optimization, Postponement Strategies).
15. The lean element **sustainability** is in charge of the systematic storage of process, product and project information in a knowledge data base. The information can be used for process and product improvements as well as reduction of the time-to-market. In spite of the necessity of a cross-project knowledge transfer, 47 % of the companies indicated that they aim for sustainability through systematic knowledge conservation (Schipper and Swets 2010).
16. Process controlling is a multidimensional approach for planning, control and optimization of business processes. Within the process controlling **key performance indicator systems** are used to reveal weak points, variance and potential for improvement (Liker and Convis 2012). 38 % of the companies use the system.
17. One-third (33 %) of the companies uses Processes **Synchronization** in the product development. The intention is to time and schedule the single work steps to achieve consistent work phases (e.g. Rhythm) (Mascitelli 2011).
18. 28 % of the companies implemented the systematical pursuit of **zero defects** in the product development process e.g. Product Reliability-Test by CAx-Methods. The intention is to decrease the drop-out-rate and the rate of change in the product development process (Linger 1993).
19. **Set-based concurrent engineering** is a new model to structure the process of developing a particular product module. Compared to the point-based approach, set-based concurrent engineering does not only develop a small number of alternative solutions for each concept module, it considers a much larger number of concepts at the beginning of the product development

process. Instead of the quick minimization of alternatives, each concept is designed, tested and analyzed parallel, until one solution is found (Morgan and Liker 2006; Sobek et al. 1999). Within the number of participants only 10 % already adopted Set-based concurrent engineering.

Figure 48.1 shows the diffusion rate of the requested lean development elements.

48.3.2 *Effectiveness and Efficiency*

In addition to the diffusion rate of lean development elements, the influence of effectiveness and efficiency were queried. The scope of possible answers varied from "very little influence" (1) to "very high influence" (4). The arithmetic mean of the responses was taken and the results are depicted in Fig. 48.2. Moreover there was a distinction between an evaluation, in which the ratings of all companies were considered (Fig. 48.2, Section 1) and an evaluation in which only the ratings were considered by the companies that have implemented the particular elements (Fig. 48.2, Section 2). A different result appears, if only the evaluations of companies are considered, that have implemented the respective element. The diffusion rate (Fig. 48.1) and the impact on effectiveness and efficiency correlate

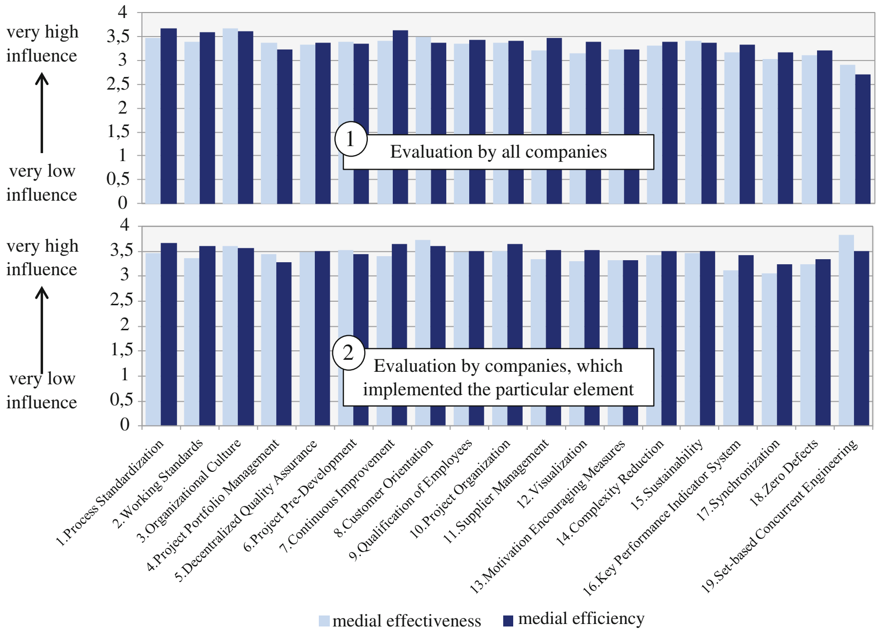

Fig. 48.2 Effectiveness and efficiency of lean development elements

significantly less. Comparing the values of Section 2 with the values from Section 1, it is striking that there is a significant difference between the valuations of some elements. Companies, which have implemented the respective elements already, on average, attach a higher impact on effectiveness and efficiency to the elements of Lean Development. Particularly, in the validation for the set-based concurrent engineering, and for the customer orientation this discrepancy becomes apparent. The set-based concurrent engineering even provides the most powerful influence to increase effectiveness. The efficiency will continue to be affected most by the process standardization. However, the evaluations of customer orientation and continuous improvement have improved significantly. The synchronization of the processes was rated worst in both categories by the companies that have introduced it.

48.4 Discussion

Figure 48.1 shows that the elements key performance indicator system (38 %), synchronization (33 %), zero-defects (28 %) and especially set-based concurrent engineering (10 %) are barely established. This could be reasoned by e.g. the complexity of the implementation or the requirements of other elements (for instance key performance indicator systems require process standardizations).

As mentioned before companies, which implemented the elements already, attach a higher impact on efficiency and effectiveness. Hence, it could be concluded that the actual benefit is higher than the expected influence.

Especially the validation of the elements customer orientation (60 % implementation) and set-based concurrent engineering shows a discrepancy. Therefore companies, which have not established the elements, assume a lower influence of the elements. Probably, the companies do not see the need for the implementation of the element or want avoid the higher effort (time and cost).

Set-based concurrent engineering was mostly established by the companies with the highest number of employees and annual turnover. This could be caused by e.g. the effort of implementation or the high requirement for employee capacity. Furthermore, set-based concurrent engineering, as a lean develop element, does not seem to be lean at first, because of the great amount of considered alternatives at the beginning. In contrast, small and medium-sized companies barely adopt the element. In this field is need for action.

48.5 Conclusion

To increase the effectiveness and efficiency in product development, more and more companies introduce lean development. It can be summarized from the study that 60 companies of varying size and industry already implemented some elements of lean development. Another outcome of the study is that all elements are trusted to have a good to very good influence on the effectiveness and efficiency in product development, regardless whether the ratings of all companies or just of the companies that introduced the element are considered. Nevertheless, the discrepancy between the two analyses is clear. Companies that have introduced elements of the lean development, attach, on average, a higher impact on effectiveness and efficiency to them.

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Chapter 49
Mixed-Model U-Line Balancing and Sequencing in Lean Production

Jing Zha and Xiang-feng Zeng

Abstract Just-in-time, flexible operators, level production and flow manufacturing are main features of lean production. Based on these features, the paper builds a mathematical model of mixed-model U-line balancing and sequencing problem. The objectives of the model are minimizing the workstations number at the given cycle time, balancing workload, minimizing setup time and leveling the material flow. An improved multi-objective co-evolutionary ant colony algorithm is developed to solve this NP-hard problem. The algorithm utilizes multiple ant colonies with different objectives and each ant colony includes two ant sub-colonies to construct line balancing and sequencing solution independently. All ant colonies exchange information regularly. The Pareto optimal solutions are found by ant colonies' collaboration. Finally example calculation indicates the proposed algorithm's effectiveness.

Keywords Lean production · Line balancing · Mixed-model U-line · Multi-objective co-evolutionary ant colony algorithm · Sequencing

49.1 Introduction

Line balancing and model sequencing are two important problems to design and manage mixed-model line. The two problems are extensively dealt with independently or sequentially in the literatures and have been confirmed as NP-hard problems. In fact, they are tightly interrelated with each other. The mixed-model line can not be in the optimal state if two problems are considered independently or sequentially. Merengo (1999) analyzed the interrelationship between line balancing and model sequencing solution. Kim and Kim (2000) began to apply a

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co-evolutionary algorithm based on genetic operators to solve the two problems simultaneously.

Toyota's success triggers the research and application of lean production. Lean production prefers to U-line because U-line has many advantages (Monden 1983). For example, workstations on U-line are located more close. It will short the operator's walking distance when he handles several machines and also benefits to operator's communication and problem-shooting by team work. Miltenburg (2001) reviewed U-line's theory and application principles. Miltenburg (2002) used genetic algorithm to solve U-line balancing and sequencing problems simultaneously. Kim et al. (2006) proposed an endosymbiotic evolutionary algorithm to minimize the absolute deviation of workloads (ADW) among workstations. Kara et al. (2007a) developed an improved simulated annealing to minimize the workstations number and ADW.

There are many unique elements in lean production. When U-line is designed and utilized, the manager should consider the requirement of other elements of lean production. That means the optimal objectives are multiple. References (Miltenburg 2002; Kim et al. 2006; Kara et al. 2007a, b) transfer the multi-objective problem to the single objective problem by assigning subjective weight to each objective and can not obtain the Pareto optimal solutions.

In order to meet the requirement of lean production, the paper builds the mathematical model of mixed-model U-line balancing and sequencing problem in the next section. In Sect. 3, an improved multi-objective co-evolution ant colony algorithm is proposed to solve the NP-hard. In Sect. 4, an example is solved and the calculation result indicates the proposed algorithm's effectiveness. The last section is conclusion.

49.2 Problem Analysis and Mathematical Model

49.2.1 Problem Statement

In a mixed-model U-line, multiple models are manufactured or assembled one by one. It is more suitable for manufacturing many products with low volume. In order to facilitate management, the minimum part set (MPS) is manufactured repetitively in a mixed-model line. Suppose there are PN kinds of product manufactured in a U-line and the model p's volume in planning horizon is D_p. D_c is the greatest common divisor of D_p ($p = 1, \ldots, PN$). $d_p = D_p/D_c$. $d_{MPS} = \sum_{p=1}^{PN} d_p$. $MPS = (d_1, d_2, \ldots, d_{PN})$. For example, suppose $PN = 3$, $D_A = 100$ and $D_B = D_C = 200$. Therefore $MPS = (1, 2, 2)$ and will be manufactured for 100 times. Model sequencing problem is about deciding an optimal model launching sequence in MPS. For example, A_B_C_B_C is a feasible model sequence for $MPS = (1, 2, 2)$.

In a U-line, there are many serial workstations which implement one or more tasks. Semi-finished products or parts sequentially go through each workstation at a certain speed. After going through all workstations, they are manufactured to finished goods. Line balancing is about how to assign tasks to the serial workstations optimally. In general, it needs to meet some constraints, such as precedence between task implementation because of processing technology or product design's requirement and so on.

49.2.2 Optimization Objectives

Just-in-time, flexible operators, level production and flow manufacturing are main features of lean production. Based on these features, the paper considers the following optimization objectives.

49.2.2.1 Minimizing the Workstations Number at the Given Cycle Time

There are two types of U-line balancing: ① minimizing the workstations number given the cycle time; ② minimizing the cycle time given the workstations number. Cycle time decides the production speed. Just-in-time requires the production speed should meet customer's needs exactly, without delay nor in advance, because inventory is regarded as a waste. Flexible operators also mean the operators in a U-line should be increased or decreased according to the customer's needs. Therefore, choose the former objective, as expression (49.1). $S_k = 1$ represents the workstation k has been assigned tasks and 0 otherwise. m is the upper bound of workstation number.

$$Min \quad f_1 = \sum_{k=1}^{m} S_k \tag{49.1}$$

49.2.2.2 Balancing Workload

Workload is the time of the workstation implementing its tasks. In order to achieve just-in-time and flow manufacturing, smooth production should be ensured. Workload over the cycle time will cause unfinished tasks and line block or stop. Workload less than the cycle time will reduce line efficiency. Therefore, workload among workstations and among stages in the same workstation should be balanced. See expression (49.2). C represents the cycle time. L_k represents the execution time of workstation k in stage q and see expression (49.11). $m_{\min}$ is the lower bound of workstations number.

$$Min \quad f_2 = \frac{\sum_{k=1}^{m} \sum_{q=1}^{d_{MPS}} (C - L_{qk})^2}{m_{\min} \times d_{MPS}} \tag{49.2}$$

49.2.2.3 Minimizing Setup Time

When the product in the workstation switches from one kind to another, it exits setup time besides tasks execution time. Setup time isn't value-added time and the total setup time should be reduced as much as possible. See expression (49.3). $B = b_1\_b_2\_...b_q...\_b_{d_{MPS}-1}$ is the model sequence for MPS. b_q represents the model of the position q in sequence B. $U_{b_1 \cdot b_{q+1}}$ represents the setup time when switching from one model to another.

$$Min \quad f_3 = \sum_{q=1}^{d_{MPS}-1} U_{b_q \cdot b_{q+1}} + U_{b_{d_{MPS}} \cdot b_1} \tag{49.3}$$

49.2.2.4 Leveling the Material Flow

In order to make sure stable production of assembly line, production line and supplier, reduce in-process inventory and avoid some parts shortages and some other parts backlog, leveling production, especially leveling the material flow is required. See expression (49.4). For $MPS = (d_1, d_2, \ldots, d_{PN})$, the average demand rate of model p is d_p/d_{MPS}. The demand of model p from start to stage q is $q \times (d_p/d_{MPS})$. $Z_{pe} = 1$ represents the position e of sequence B is model p and 0 otherwise. The production volume of model p from start to stage q is $\sum_{e=1}^{q} z_{pe}$. At stage q, The deviation's square of model p between the demand and production is $[\sum_{e=1}^{q} z_{pe} - q \times (d_p/d_{MPS})]^2$. Leveling the material flow requires to minimize the total deviation.

$$Min \quad f_4 = \sum_{q=1}^{d_{MPS}} \sum_{p=1}^{PN} \left(\sum_{e=1}^{q} z_{pe} - q \times \frac{d_p}{d_{MPS}} \right)^2 \tag{49.4}$$

49.2.3 Mathematical Model

Based on the above analysis and the integer programming formulation developed by Urban (1998) for the U-line balancing, the mathematical model of mixed-model U-line balancing and sequencing problem is developed as below:

$$Min \quad F = [f_1, f_2, f_3, f_4] \tag{49.5}$$

$$s.t. \quad \sum_{k=1}^{m} (x_{ik} + y_{ik}) = 1, \quad i = 1, \ldots, n \tag{49.6}$$

$$\sum_{k=1}^{m} (k \times x_{ik}) \leq \sum_{k=1}^{m} (k \times x_{jk}), \forall (i,j) \in P \tag{49.7}$$

$$\sum_{k=1}^{m} (k \times y_{ik}) \geq \sum_{k=1}^{m} (k \times y_{jk}), \forall (i,j) \in P \tag{49.8}$$

$$\sum_{p=1}^{PN} z_{pq} = 1, q = 1, \ldots, d_{MPS} \tag{49.9}$$

$$\sum_{q=1}^{d_{MPS}} z_{pq} = d_p, p = 1, \ldots, PN \tag{49.10}$$

$$L_{qk} = \sum_{i=1}^{n} (t_{FZ_{qk} \cdot i} \times x_{ik}) + \sum_{i=1}^{n} (t_{BZ_{qk} \cdot i} \times y_{ik}), q = 1, \ldots, d_{MPS}, k = 1, \ldots, m \tag{49.11}$$

Different from a straight line, U-line consists of two sides: front side and back side. So a task can be assigned to a workstation's front side from front to back and also can be assigned to a workstation's back side from back to front. $x_{ik} = 1$ represents task i has been assigned to the workstation k's front side and 0 otherwise. $y_{ik} = 1$ represents task i has been assigned to the workstation k's back side and 0 otherwise. The constraint (49.6) makes sure that each task should and only should be assigned to one station's one side. Constraint (49.7) and Constraint (49.8) makes sure that task's assignment conform to the precedence's requirement. The constraint (49.9) makes sure that the model in the position q of sequence B is one from PN kinds of models. The constraint (49.10) makes sure that the number of model p in the sequence B equals d_{MPS}.

49.3 An Improved Co-evolutionary Ant Colony Algorithm

The co-evolutionary ant colony algorithm utilizes multiple ant colonies. Each ant colonies includes two ant sub-colonies to construct line balancing and sequencing solution. All ant sub-colonies both have relative independent evolution strategies and share information regularly in evolution process. The Pareto optimal solutions are found by multiple ant colonies' collaboration (Kowalczuk and Bialaszewski 2006).

49.3.1 Single Objective Co-evolutionary Ant Colony Algorithm

49.3.1.1 Map and Pheromone

For an ant of line balancing, map is a graph $G_c^1 = (I^1, L^1)$. I^1 is the set of tasks and tasks' position in task sequence A. L^1 is the link set of tasks and tasks' position in A. Pheromone τ_{ij}^1 is defined as the expectation which task i should be assigned to position j. When a balancing ant completes a tour in the map, a feasible task sequence $A = a_1\_a_2\_\ldots\_a_n$ is constructed.

For an ant of model sequencing, map is a graph $G_c^2 = (I^2, L^2)$. I^2 is the set of models and models' position in model sequence B. L^2 is the link set of models and models' position in B. Pheromone τ_{ij}^2 is defined as the expectation which model i should be assigned to position j. When a sequencing ant completes a tour in the map, a feasible model sequence $B = b_1\_b_2\_\ldots\_b_{d_{MPS}}$ is constructed.

49.3.1.2 Generating an Integrated Solution

Two ant sub-colonies have the similar process of solution construction as below because both solutions are sequences.

STEP 1: Initialization. Position $k = 1$. $Tabu = \phi$ records assigned tasks for a balancing ant or models for a sequencing ant.
STEP 2: Check the set of feasible tasks or models candidates CAD for position k. For a sequencing ant, the candidates are unassigned models in MPS. For a balancing ant, the candidates are unassigned tasks which preceding tasks or successive tasks are none or have been assigned. If the task has no preceding tasks, it can be assigned to the front side of a workstation. If the task has no successive tasks, it can be assigned to the back side and a mark "-" is added before the task in CAD.
STEP 3: If there are feasible candidates in CAD, assign a candidate i to position k using the pseudo-random-proportional rule (Dorigo and Stutzle 2004) as expression (49.12). $Tabu = Tabu \cup \{i\}$. $k = k + 1$. Turn to STEP 2. If CAD is none, an ant has completed a tour and a sequence has been constructed. Sub-procedure ends.

$$i = \begin{cases} I_1 = \arg\max\limits_{i \in CAD} \left[(\tau_{ik})^{\alpha} (\eta_i)^{\beta} \right] & r \le r_0 \\ I_2 : p_{ik} = \dfrac{(\tau_{ik})^{\alpha} (\eta_i)^{\beta}}{\sum\limits_{j \in CAD} \left[(\tau_{jk})^{\alpha} (\eta_j)^{\beta} \right]} & r > r_0 \end{cases} \tag{49.12}$$

If random variable $r \in [0, 1] \le r_0$, assign the candidate i with the largest $(\tau_{ik})^{\alpha} (\eta_{ik})^{\beta}$, otherwise by the ratio of p_{ik}. η_i is the heuristic weight of a task or model i.

Suitable heuristic information will help an ant with constructing a solution with high quality. So η_i is different for each ant colony according to the different objective. It will be explained later.

49.3.1.3 Calculating the Fitness of an Integrated Solution

Every task sequence in ant sub-colony of line balancing and every model sequence in ant sub-colony of sequencing are combined one-to-one to form an integrated solution. For example, if there are 5 ants in each sub-colony, there are $5*5 = 25$ integrated solutions. Before calculating the fitness, it should obtain a real line balancing solution according to a task sequence and a model sequence.

The workstation, which has only front side or back side, is called a regular workstation and includes one work zone. Each model in MPS passes by the regular workstation once. The workstation which has both front side and back side is called a crossover workstation and includes two work zones. Which model is in the front zone and which model is in the back zone is very important question and influences the execution time of workstation. Define NWZ_k as the number of work zones from workstation k to the last workstation.

According to U-line's layout, see as Fig. 49.1, the last workstation m must be a regular one and includes one work zone. $NWZ_m = 1$. If workstation *(m-1)* is a regular one, $NWZ_{m-1} = 2$. Else if is a crossover one, $NWZ_{m-1} = 3$. In turn, NWZ_k of the each workstation can be calculated. When the model in the back zone of workstation k is the one in the position q of sequence B, the model in the front zone is the one in the position $(q + NWZ_k - 1)$ of B. For example, workstation 3 in Fig. 49.1 is a crossover workstation. $NWZ_3 = 4$. Suppose $B = b_1\_b_2\_b_3\_b_4\_b_5\_b_6$. When the model in the back zone of workstation 3 is b_1, the model in the front zone is b_4. $q + NWZ_k - 1 = 1 + 4 - 1 = 4$. In turn, all model mixes which appear in the workstation 3 are (b_4, b_1), (b_5, b_2), (b_6, b_3), (b_1, b_4), (b_2, b_5), (b_3, b_6).

The process of assigning tasks to workstations is as follows. Check each task in turn from the last task in sequence A. Firstly assumes assigning the current task to the current workstation. If the task has no prefix "-", it is assigned to the front side

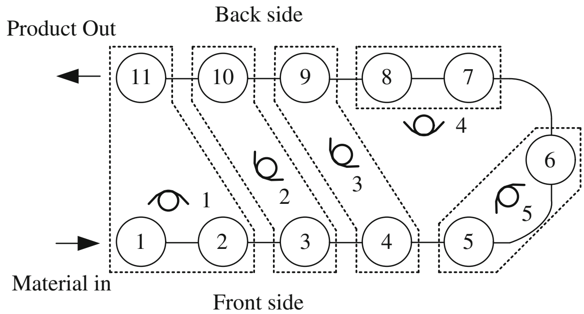

Fig. 49.1 An example of the U-line's layout

and otherwise, assigned to the back side. Secondly decide whether the current workstation is a regular or crossover one if assigned the current task. If it is a crossover one, calculate the model mixes. Thirdly calculate the workstation's execution time. If the time exceeds the cycle time, the task can not be assigned to the current workstation and open the next workstation to be assigned the task. Else if the time do not exceed the cycle time, assign the task to the current workstation and check the next task in sequence A until all tasks have been assigned to a workstation. And then f_1, f_2, f_3 and f_4 can be calculated according to expression (49.1–49.4).

49.3.1.4 Pheromone Update

After an ant constructs a solution, the pheromone on the ant's trail will be decreased as expression (49.13) in order to encourage the later ants explore more new trails. It is called local pheromone update rule. After all ants in one iteration construct solutions, the pheromone on the trail of the ant with the best solution will be increased as expression (49.14) in order to encourage more later ants construct this best solutions. It is called global pheromone update rule.

$$\tau_{ij} = (1 - \rho)\tau_{ij} \tag{49.13}$$

$$\tau_{ij} = \tau_{ij} + \Delta\tau_{ij}^{best} \tag{49.14}$$

If some trail's pheromone are too high and some trail's pheromone are too small, the ability of ants exploring new trails is reduced and the algorithm can only find the local optimum, not the global optimum. Therefore, the trail's pheromone would be restricted between $\tau_{\max}$ and $\tau_{\min}$.

49.3.2 Multi-Objective Co-evolutionary Ant Colony Algorithm

The algorithm utilizes five ant colonies with independent search process. Four ant colonies pursue one objective, like the ant colony mentioned above. The five ant colony purses multiple objectives. When constructing a sequence, the ants in different colonies use different heuristic weight η_i as Table 49.1.

After some iteration, four single objective ant colonies and one multi-objective ant colony exchange the optimal solutions.

All non-dominated solutions found by ants are saved in a Pareto set $NDS(t)$. A niche mechanism, see as expression (49.15–49.16), is used to evaluate the solutions.

Table 49.1 Ant colonies' heuristic weight η_i

Objective	η_i of balancing ant	η_i of sequencing ant
f_1	$\eta_i^{(1)} = t_i$	–
f_2	$\eta_i^{(2)} = 1/(C - t_i - t_j)$	–
f_3	–	$\eta_i^{(3)} = Q_0/f_{3(i)}$
f_4	–	$\eta_i^{(4)} = Q_0/f_{4(i)}$
$f_1f_2f_3f_4$	$\eta_i^{(5)} = \eta_i^{(1)} \times \eta_i^{(2)}$	$\eta_i^{(6)} = \eta_i^{(3)} \times \eta_i^{(4)}$

Note t_i the execution time of task i; j the last task in assigned task sequence A; Q_0 constant; $f_{3(i)}$ the value of f_3 if model i is added to the sequence B; $f_{3(i)}$ the value of f_4 if model i is added to the sequence B

$$NicheCount(i) = \sum_{j \in NDS(t), j \neq i} S_{(d_{ij})} \tag{49.15}$$

$$S_{(d_{ij})} = \begin{cases} 1 - (d_{ij}/\delta_{share}) & d_{ij} < \delta_{share} \\ 0 & otherwise \end{cases} \tag{49.16}$$

$d_{ij} = ||F_i - F_j||$ is the distance between solution i and j in the Pareto set. δ_{share} is the radius of niche. Because the solution with less *Niche Count* has more possibilities to guides the later ants searching the Pareto front surface evenly and exactly, the solution with the lest *Niche Count* is regarded as the best solution for the five multi-objective ant colony to execute the global pheromone update.

49.4 Illustrative Example

The precedence relationship and task time of three products are showed as Table 49.2. In the planning horizon, the ratio of three products' needs is 2:3:5. The cycle time is 32. The setup time is showed as Table 49.3.

The parameters in the algorithm are set as below. $\alpha = 2$. $\beta = 0.5$. $\tau_{\min} = 0.1$. $\tau_{\max} = 0.9$. $\tau_0 = 0.5$. $\rho = 0.1$. $r_0 = 0.6$. Ant number in each colony is 10. $\delta_{share} = 30$.

The example is calculated by co-evolutionary ant colony (CACO) and simple ant colony algorithm (ACO) for 10 times. The result is evaluated by D (see expression 49.17) and Δ (see expression 49.18) (Zitzler et al. 2003). D measures the diversity of Pareto set. Bigger D, more diversity. Δ measures the even of Pareto set. Smaller Δ, more even.

$$D = \sqrt{\sum_{i=1}^{m} \left(\max_{j=1}^{n} f_i(X_j) - \min_{j=1}^{n} f_i(X_j) \right)^2} \tag{49.17}$$

Table 49.2 Three products' production information

No	Preceding			Task time			No	Preceding			Task time		
	A	B	C	A	B	C		A	B	C	A	B	C
1	/	/	/	2.5	2.5	2.5	21	10	20	10,20	17	19	18
2	1	1	1	2	2	2	22	21	21	21	8	8	8
3	/	2	2	0	8.0	8.0	23	22	22	22	7	7	9
4	2	/	2	4.0	0	6.0	24	23	23	23	5	5	5
5	3	3,4	4	16	20	18	25	24	24	24	6	6	6
6	5	5	5	9	9	9	26	/	/	/	5	5	5
7	/	/	/	0	4	4	27	25,19	25,26	19,26	5	5	5
8	/	/	/	2.5	2.5	2.5	28	/	/	24	0	0	2
9	/	/	/	2.5	2.5	2.5	29	27	27	27	1	1	1
10	8,9	8	9	7	7	7	30	28,29	28	29	3	3	3
11	8	/	/	3	0	0	31	30	30	30	3	3	3
12	8	8	8	5	5	5	32	31	31	31	1	1	1
13	2	2	0	9	9	0	33	23	23	23	4	4	4
14	6,7	7,13	6,13	13	13	12	34	22	22	22	2	2	2
15	/	/	/	2.5	2.5	2.5	35	32,33	32,34	33,34	2	2	2
16	11,14	14,15	11,14	6	6	6	36	35	35	35	1	1	1
17	16	16	16	6	6	6	37	34	34	34	2	2	2
18	/	/	/	2.5	2.5	2.5	38	36,37	36	36	1	1	1
19	17	18	17,18	3	3	3	39	38	38	38	1	1	1
20	/	/	/	3	3	3							

Table 49.3 Setup time

	A	B	C
A	0	4.44	3.33
B	3.49	0	0.82
C	2.91	1.59	0

$$\Delta = \sum_{i=1}^{n} \frac{|d_i - \bar{d}|}{n} \tag{49.18}$$

Note n number of Pareto solutions; d_i the distance of two neighbor solutions in the Pareto set. $\bar{d}$ mean of d_i.

Calculation results of mean value by 10 times are showed as Table 49.4. CACO proposed by the paper are dominated ACO.

Table 49.4 Calculation results (mean value by 10 times)

	ACO	CACO
D	13.78	17.01
Δ	2.57	2.05

Table 49.5 Pareto solutions (part)

No	Balancing	Sequencing	f_1	f_2	f_3	f_4
1	{26,7,1,18,-36,8,12,15,-39,20,11,2} → {-35,-33,13,3,-32,-38,-31,-30,-28,4} → {-37,-34,9,-29,-27,-19,10,-17} → {-25,5,-16} → {-14,21} → {-24,6,22,-23}	CCBCBBAACC	6	5.49	3.90	10.82
2	{-39,1,18,-36,20,8,15,26,11,12,7} → {-35,-32,2,-33,3,13,-38,9,4,-37} → {-31,10,-34,5} → {6,-30,21} → {-29,22,-27,23,-19,-17} → {-28,14,-25,16,24}	BCCABBCACC	6	5.74	2.63	16.82
3	{9,26,7,-36,1,15,8,20,10} → {-39,12,18,-38,11,-35,21} → {2,13,3,22,-37,4,-34} → {23,24,33,-32,-31,-30,-29,-27} → {-19,5,6} → {-17,25,14,-16,28}	CBCACBACBC	6	6.38	1.10	19.47
4	{20,7,26,-36,15,-39,-38,18,-37,1,9,8,11,2} → {4,3,-35,-33,13,-32,12,-31} → {-34,10,-30,5} → {21,-28,22} → {6,23,14} → {24,25,-29,-27,16,17,-19}	CCCCCAABBB	6	7.49	13.03	8.17
5	{18,8,11,15,7,9,10,26,20} → {-39,-36,-35,21,22} → {1,2,13,-33,3,12,4} → {-32,-38,-37,5,23} → {6,14,-34,-31,24} → {28,-30,25,-29,16,17,-27,19}	CCCBBBCAAC	6	6.61	5.17	8.65
6	{15,8,12,-36,9,-39,7,1,20,18,2} → {-38,26,11,-35,3,10,13,4} → {-37,-32,-31,-34,-33,5} → {21,-30,22} → {-29,6,-27,-28,-19,-25,-17} → {-16,-24,14,-23}	CCABCBCABC	6	7.06	1.63	18.75

Table 49.5 shows 6 Pareto solutions in the Pareto set for manager to select. If workload balancing is more important, solution 1 should be choose. If setup time minimization is more important, solution 3 should be choose. If material flow leveling is more important, solution 4 should be choose. If four objects have the same priority, solution 5 is more suitable.

49.5 Conclusion

Lean production prefers to mixed-model U-lines. In order to enhance the performance of U-lines, it should consider the requirement of just-in-time, flexible operators, level production and flow manufacturing when balancing and sequencing mixed-model U-line. The paper analyzes the problem and builds the multi-objective optimization mathematical model. And then proposes a co-evolutionary ant colony algorithm to solve the NP-hard problem. The calculation result indicates the Pareto solutions which found by the proposed algorithm have more diversity and are more even than those found by the simple ant colony algorithm. The co-evolutionary ant colony algorithm is effective.

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Chapter 50
Production Cycle of the Single-Piece and Small-Batch Mechanical Processing Based on Learning Curve

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Abstract For the production cycle of single-piece and small-batch mechanical processing is difficult to determine, making delivery time does not accurately calculate, so this article presents reverse derivation learning curve, to study production cycle of single-piece and small-batch mechanical processing, to summary the formula to calculate the production time.

Keywords Learning curve · Production cycle · Production scheduling · Single-piece and small-batch mechanical processing

50.1 Introduction

Learning curve, also known as the skilled curve, is a dynamic production function, first generated in the aircraft manufacturing industry. It says in the production process, with the cumulative increase in production, product unit of work will gradually decline, but after the cumulative production reaches a certain number, product unit of work will stabilize.

But in general situation learning curve is just theoretical application, knowing the first production time, the learning rate of workers, the n-production time could be obtained. However in practical production, a Enterprise accepts a single-piece and small-batch order, it needs to determine whether the order can be complete in time, this needs to calculate production cycle. But in the process of determining

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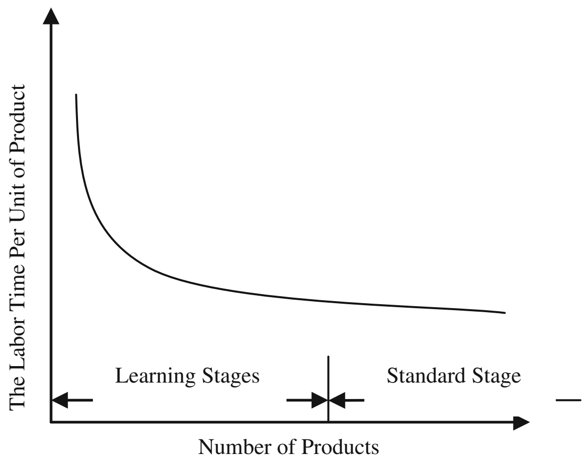
the production cycle, the learning coefficient is unknown; the standard time of the production of certain products is unknown too, so we need to determine learning coefficient and standard time in order to projected single and small batch mechanical processing time.

50.2 Study of Learning Curve

Learning curve reflects the cumulative average working hours and cumulative production of law known as the learning effect. The so-called learning effects, refers to when a person or an organization to complete a repeat production (task), the time of complete a unit of product will be gradually reduced as the product of the number increased, and then stabilized. According to the statistical analysis, relationship between time consuming of produce per unit of product and cumulative production is exponent, as shown in Fig. 50.1. This curve consists of two stages: first stage is learning stage, in this stage the production time of produce per unit of product gradually decrease with the increase of the number of products; Second stage is standard stage, in this stage the production time per unit of product are basically stable, the learning effect is negligible, standard time is available for production. As shown in Fig. 50.1, the learning curve, it represents relationship between direct labor hours per unit of product and cumulative production.

For different product or different enterprises, learning rates may be different. The learning curve decline very fast at the beginning, then gradually flattens out. In addition to the aircraft manufacturing industry, other industries such as automotive, petrochemical, semiconductor, synthetic rubber, synthetic fiber fabric industry have found a similar phenomenon. Despite the different time- cost at different rates, but the phenomenon whenever cumulative production increases is doubled, product time–cost by the same percentage regularly decreasing is similar.

Fig. 50.1 Learning Curve



50.3 Characteristics of Single-Piece and Small-Batch Mechanical Processing

Single and small batch production is typical manufacture-to-order (MTO), it usually the produce of special products. The production process is not repeated, such as the manufacture of ships, heavy machinery and equipment, large-scale hydroelectric generating set. The fierce market competition and the diversification of user needs, make multi-species, single and small batch production mode into the mainstream. Small batch production means to produce single product is basically a low-volume demand for dedicated production and its characteristics are similar to the single-piece production. Mode of production of single and small piece of processing are the main features:

(1) Product range is relatively more. Single and small batch processing enterprises are produced by a single mode of production, the details of the requirements of the customer orders tend to vary, leading to enterprise-to-order product categories.
(2) Production volume is small, namely "the small number and diversified demand". Single and small batch are different from production-to-stock who producing thousands of small quantities each batch of products.
(3) Production process of low repetition rate and changes frequently, uses general equipment, organizes production according to process principles.
(4) Poor stability of production plan, the degree of specialization is low.

Characteristics of single and small bath of mechanical processing determine its production process is different from mass production.

50.4 Production Cycle of Single-Piece and Small-Batch Mechanical Processing Based on Learning Curve

50.4.1 The Establishment of the Learning Curve Mathematical Model

Changes in the learning curve of exponential function, as shown in Fig. 50.2:

The learning curve can be represented by the following formula:

$$t_X = t_1 X^{-a} \tag{50.1}$$

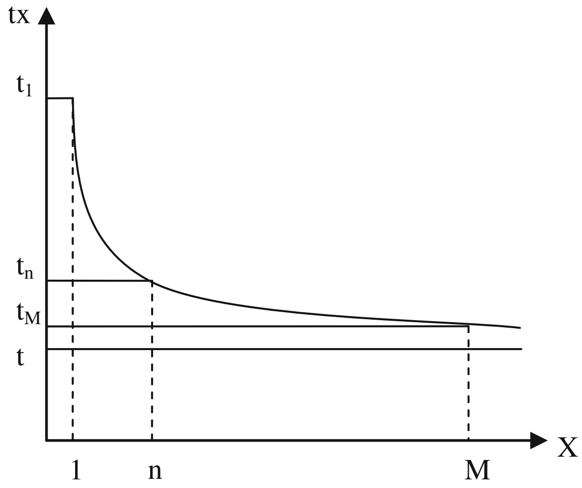
t_1 is a processing time of the first new products,

a is learning factor,

t_x represents the time of x product production,

The total time of producing m product:

Fig. 50.2 Learning Curve



$$T_{\text{total}} = t_1 + t_2 + \ldots\ldots t_m \tag{50.2}$$

By measuring the first single processing time t_1 and single t_n processing times for n, you can calculate the product processing learning factor a:

$$t_n = t_1 n^{-a} \tag{50.3}$$

$$a = -\log_n \frac{t_n}{t_1} \tag{50.4}$$

Its processing cycle using t_1, t_n is calculated as follows:

$$\begin{aligned} T_{\text{total}} &= \int_1^m T_X \mathrm{d}X \\ &= \frac{t_1}{1-a}\left(m^{1-a} - 1\right) \\ &= \frac{t_1}{1+\log_n \frac{t_n}{t_1}}\left(m^{1+\log_n \frac{t_n}{t_1}} - 1\right) \end{aligned} \tag{50.5}$$

Single parts and small batch production batch changes, in order to simplify use of it, now determine standard processing of such products at manufacturing level for t_m, t_m is determined to make processing of two adjacent product timing error is less than a certain percentage, error values are different for different Enterprise, whose error value b will depend on the specific circumstances:

$$\frac{t_{M+1} - t_M}{t_M} < b\,\% \tag{50.6}$$

Calculated approximation of the standard processing time of the products t_M, then calculate the product total processing time of production according to standard processing time, assuming the production lot to m, when m < M:

$$\begin{aligned} T_{\text{total}} &= \int_1^m T_X \mathrm{d}X \\ &= \frac{t_1}{1-a}\left(m^{1-a}-1\right) \end{aligned} \tag{50.7}$$

when m < M:

$$\begin{aligned} T_{\text{total}} &= \int_1^M T_X \mathrm{d}X + (m - M)\, t_M \\ &= \frac{t_1}{1-a}\left(M^{1-a}-1\right) + (m - M) t_M \end{aligned} \tag{50.8}$$

50.4.2 Application of Mathematical Model About Learning Curve

A manufacturing enterprise producing a batch of products, volume 35, determination the 1th product production time is 300 h, the 4th product production time is 237 h, according to Wright formula $t_X = t_1 X^{-a}$ can extrapolate the learning factor a of the enterprise is 0.16.

The preparation of the plans of the enterprise will be adjacent to two of the processing time error control in less than 2 %.

According to

$$\frac{t_{M+1} - t_M}{t_M} < b\,\%$$

M-approximately equal to 8.That is, from the beginning of production of the 8th product, its single piece production and processing time are close to the standard processing time, t8 = 215.1, we can think that one-piece standard processing time t_M is 215.1 h, the enterprise produces these products from the total machining time T is:

$$\begin{aligned} T_{\text{total}} &= \frac{t_1}{1-a}\left(M^{1-a}-1\right) + (m - M) t_M \\ &= \frac{300}{1-0.16} + (8^{1-0.16} - 1) + (35 - 8) * 215.1 \\ &= 1691.4 + 5807.7 \\ &= 7499.1 \end{aligned}$$

50.5 Conclusion

This paper through derivate the learning curve, draw unified model for single parts and small batch a mathematical formula determined the production cycle of the product, it's to single parts and small batch manufacturing enterprise of product production cycle of sure has a certain significance.

Chapter 51
Research on Disassembly Line Balancing Problem in the Presence of Uncertain Cycle Time

Bi-yu Liu, Wei-da Chen and Sheng Huang

Abstract In this paper, we discussed the disassembly line balancing problem (DLBP) in the presence of uncertain cycle time. A multi-objective mathematical optimization model was established to minimize workstation equilibrium index and demand index. And Genetic Algorithm (GA) was developed to solve this model. Some works were done as follows: firstly, generating initialized populations combining heuristic with stochastic methods; Secondly, developing a unique principle for gene decoding, which leads to efficient disassembly line balancing; Additionally, converting iteration process to matrix operators based on precedence matrix, which makes it quickly to find the optimal solutions. Finally, given a simulation experiment to get the optimal solutions in Matlab 7 and verify the efficiency of this proposed algorithm.

Keywords Disassembly line balancing problem · Genetic algorithm · Multi-objective model · Uncertain cycle time

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51.1 Introduction

Disassembly operations can be completed not only in a single disassembling workstation, but also in a disassembling unit or disassembling lines (Wiendahl and Burkner 1999; Wiendahl et al. 1998; Gungor and Gupta 1999). In the face of the large-scale product disassembly, disassembly line being organized in flow shop began to gain attention and application so that improve the efficiency of product disassembly and promote disassembly industrialization. It is defined as the disassembly process which consists of a series of disassembly operations elements, each operating elements corresponding to constant operating time, and there exist precedence among some of the operating elements. The disassembly line with various returned cores is often in highly non-equilibrium state, how to maintain its balance and maximize the disassembly efficiency is a very important and urgent problem which should be solved.

The assembly line balance problem research, mainly concentrated in the complete removal. Gungor et al. (2001) and Gungor and Gupta (2001) first proposed the disassembly line balancing problem and developed an algorithm for solving the DLBP in the presence of failures with the goal of assigning tasks to workstations in a probability to minimize the cost of defective parts. (McGovern et al. 2003; McGovern and Gupta 2003) first proposed applying combinatorial optimization techniques to the DLBP. McGovern and Gupta (2004a, b, c, 2007a, b, 2006) later compared various combinatorial optimization techniques for use with DLBP. Koc et al. (2009) used two accurate calculation formulas, i.e. dynamic programming (DP) and integer programming (IP) and adopt AND/OR GRAPH (AOG) shows the priority of tasks in the model to research DLBP, but the exact algorithm can only solve the small scale problems. A recent book by Filip (2011) is helpful in understanding the general area of disassembly.

These literatures consider only single objective in constructing optimization model and assuming constant cycle time in solving this problem, but in these single targets they often affect or even conflict with each other. Therefore, it's more realistic to consider integrated multiple targets in arranging the disassembly path. This paper presents a multi-objective model considering both equilibrium index and demand index in the presence of uncertain cycle time. In view of the superiority and effectiveness of GA in solving combinatorial optimization problems, we design GA for DLBP and simplify the difficulty in solving problem and set a unique chromosome decoding rule in the determination of cycle time which improves the disassembly line balance efficiency greatly. In operator designing, we design a GA operator based on precedence matrix which can convert iterative procedure to matrix operation and has a good adaptability to target function. So this algorithm has faster convergence speed, and can quickly obtain the optimal solution. The simulation experiment results show the effectiveness of the algorithm.

51.2 Multi-Objective Optimization Model for DLBP

For ease of modeling, some assumptions are given as follows:

- Each product is disassembled completely.
- All parts are no defect when being disassembled.
- Disassembly time of each component is deterministic, constant and integer.
- Each task is assigned to exactly one workstation.
- There are no parallel workstations, namely the workstation is linear arrangement.
- The sum of the part disassembly time of all parts assigned to a workstation must not exceed CT.
- Part precedence relationships must be enforced.

The disassembly line balancing problem seeks a sequence which: is feasible, minimizes workstations, and ensures similar idle times, as well as other end of life specific concerns. This paper seeks to fulfill four objectives including cost, profit, equilibrium index and demand index. The mathematic model is described as:

$$Min\, Z = \sum_{n=1}^{N} (CT - ST_n)^2 + \sum_{m=1}^{M} m \cdot d_m \tag{51.1}$$

$$s.t.\ ST_n = \sum_{m=1}^{M} (t_m \cdot x_{mn})\ (n = 1, 2, \ldots, N) \tag{51.2}$$

$$\sum_{n=1}^{N} x_{mn} = 1 \quad (m = 1, 2, \ldots, M) \tag{51.3}$$

$$\bigcup_{n=1}^{N} Q_n = M \tag{51.4}$$

$$\sum_{m=1}^{M} x_{mn} = Q_n \quad (n = 1, 2, \ldots, N) \tag{51.5}$$

$$\sum_{m=1}^{M} x_{mn} t_m \le CT \ \ (n = 1, 2, \ldots, N) \tag{51.6}$$

$$\sum_{n=1}^{N} \left(nx_{jn} - nx_{in}\right) \ge 0 \quad (i = 1, 2, \ldots, M-1;\, j = 2, 3, \ldots, M;\ j > i) \tag{51.7}$$

$$\left[\sum_{m=1}^{M} t_m \Big/ CT \right] \le N \le M \tag{51.8}$$

Some notations in the model are described as follows:

CT	Cycle time
n	Serial Number of workstation
ST_n	Operating time of workstation n
N	Numbers of workstation
M	Numbers of operation elements
m	The mth operation element
d_m	Demand for parts m
t_m	Disassembling time of the mth operation element
x_{mn}	Binary value; 1 if task m is assigned to the nth workstation, else 0
S_n	Operation elements which are assigned to the nth workstation
Q_n	Numbers of operation elements in S_n.

51.3 Disassembly Precedence Relation Matrix

In this paper, we take a certain type mobile phone as research object; its parts are shown in Fig. 51.1.

We obtain precedence relation matrix which is more suitable for processing by computer through quantifying Fig. 51.2. We denote y_{ij} as a binary value; 1 if task i must be completed before task j, else 0.

For a product including n operating elements, the precedence constraints among its operation elements can be mapped into a 0–1 matrix as follows.

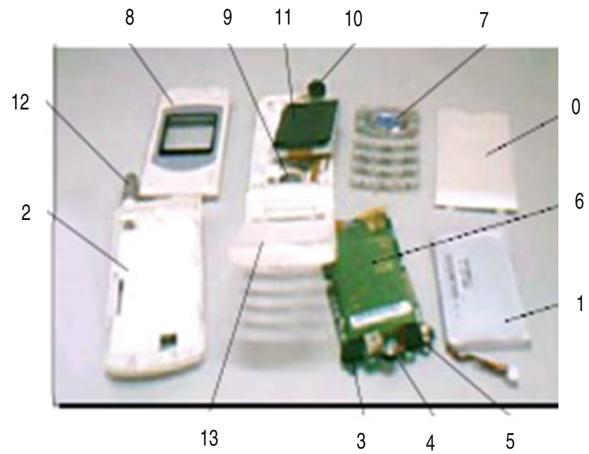

Fig. 51.1 Mobile phone parts

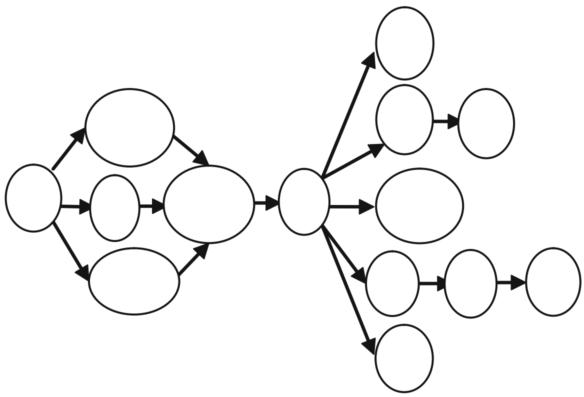

Fig. 51.2 Disassembly precedence relations

$$Gp = \begin{bmatrix}
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}$$

51.4 Genetic Algorithm Design for DLBP

GA is a general-purpose optimization algorithm. It can handle any form of objective functions and constraints without knowing the intrinsic nature of the solution during searching and also find out the global optimal solutions in greater probability during searching. Therefore, in view of the advantages of GA, we solve the model using it.

Table 51.1 Disassembly information

Task number	Disassembly time/min	Demand/(pc/min)
0	3	21
1	1	15
2	4	30
3	3	40
4	3	27
5	3	25
6	9	30
7	1	28
8	2	35
9	2	22
10	2	33
11	6	27
12	3	19
13	3	20

51.4.1 Chromosome Encoding

Coding should be solved firstly in the application and is also one of the key steps in designing it. This paper codes part numbers by real coding directly and then scheduling operation elements in a row according to the order in the assigned workstation and each corresponds to a gene location. Disassembly information for the mobile phone is shown in Table 51.1. Parts disassembly time means the average time of workers' operating, and demand is the average value for the latest week.

Assuming WS equals to 4. Figure 51.3 is the result of a chromosome coding. This chromosome describes the operation element assigned in the order.

51.4.2 Initial Population

The initialization of the first population is usually generated by random. But taking into account precedence constraints, we combine a heuristic random search method and hybrid method to generate initial population based on the priority relationship among the operations.

Assuming $a(i)$ as the feasible operation set after finishing operation i. According to the precedence relation, the condition of operation j can enter the feasible operation set $a(i)$ is that all operations should be completed before it and also it is uncompleted. Therefore, the specific steps of generating feasible operation sequence are as follows:

8	11	9	10	13	2	6	3	7	5	12	0	1	4

Fig. 51.3 A chromosome being coded

Step 1 Selecting those tasks with no precedence operations to format feasible operation set $a(i)$;
Step 2 Judging the termination condition, if the optional set $a(i)$ is empty, then stop; else go to step 3;
Step 3 Selecting a task randomly from the feasible operation set and enrolling it to gene location;
Step 4 Updating $a(i)$, deleting operations selected and adding new operations in accord with the rules, then go to step 2;
Step 5 If all operations are assigned, then stop; else go to step 2.

51.4.3 Chromosome Decoding

Decoding means assigning operation elements to workstations according to priority relationship constraints with $ST_k \leq CT(WS)$. On the determination of $CT(WS)$, for an existing allocation scheme, the increment of $CT(WS)$ is not a consecutive integer, $CT(WS)$'s increase or decrease in the quantity for each adjustment is time value of an operating element. We design a new decoding method based on this idea as follows.

Step 1 Initial CT: $CT' = \sum_{m=1}^{M} t_m \Big/ WS = 45/4 = 12$

Step 2 Allocating M operating elements to WS workstations in accordance with the order of genes in the chromosome (operating elements' allocation sequence) with CT'. Each workstation time is $ST_1, ST_2, \ldots, ST_k, \ldots, ST_{WS}$, respectively. If $ST_k \leq CT'$, then CT' is the minimal cycle time under this assignment and stop. Else go to step 3.

Step 3 Defining Δ_k as the operating time of the first operating element in the $(k+1)$th workstation and calculating $\Delta_1, \Delta_2, \ldots, \Delta_k, \ldots, \Delta_{WS-1}$ which are the increment of $CT(WS)$, where $k = 1, 2, \ldots, (WS-1)$.

The searching results are shown in Table 51.2 when $CT' = 12$.

During the first searching, we obtain

$$CT = \max_{1 \leq k \leq WS}\{ST_k\} = 14, CT' = \min_{1 \leq k \leq WS}\{ST_k + \Delta_k\} = 13$$

Obviously, $CT' < CT$.

Therefore, reassigning operating elements to each workstation with $CT' = 13$. The assignment results are shown as Table 51.3.

Table 51.2 The first searching result in decoding process ($CT' = 12$)

Workstation number	1	2	3	4
S_k	$\{8, 11, 9, 10\}$	$\{13, 2\}$	$\{6, 3\}$	$\{7, 5, 12, 0, 1, 4\}$
ST_k	12	7	12	14
$ST_k + \Delta_k$	15	16	13	–

Table 51.3 The second searching result in decoding process ($CT' = 13$)

Workstation number	1	2	3	4
S_k	$\{8, 11, 9, 10\}$	$\{13, 2\}$	$\{6, 3, 7\}$	$\{5, 12, 0, 1, 4\}$
ST_k	12	7	13	13
$ST_k + \Delta_k$	15	16	16	–

Step 4 Denoting $CT = \max\limits_{1 \le k \le WS}\{ST_k\}, CT' = \min\limits_{1 \le k \le WS}\{ST_k + \Delta_k\}$, if $CT \le CT'$, then CT is the minimal cycle time under this assignment and stop; Else go to step 2.

During the first searching, $CT = \max\limits_{1 \le k \le WS}\{ST_k\} = 13, CT' = \min\limits_{1 \le k \le WS}\{ST_k + \Delta_k\} = 15$. Obviously, $CT' > CT$, stop. The results of decoding are shown in Table 51.3 and $CT = 13$.

51.4.4 Fitness Function

The fitness function is maximum, but the objective function is minimum, in order to convert target function to seek maximum problem, we introduce a transition function C (C is constant and $C \ge \sum\limits_{n=1}^{N}(CT - ST_n)^2 + \sum\limits_{m=1}^{M} m \cdot d_m$). Calculating the fitness of each individual as follows:

$$F(p) = C - \left\{ \sum_{n=1}^{N} (CT - ST_n)^2 + \sum_{m=1}^{M} m \cdot d_m \right\} \tag{51.9}$$

51.4.5 Select Operator

We apply the famous roulette wheel selection method to select excellent quality unit and generate new populations. The main idea of this method is that the next generation inherit some excellent quality unites which are selected based on the fitness value of unites in the population in certain rules and methods, namely individual choice probability is proportional to the fitness value, and the probability that strong adaptability individuals being selected is high.

51.4.6 Crossover Operator

This paper applies two-point crossover method which generates two cross points randomly:

(1) For a chromosome including M genes, the first cross point is *position*1 which is a stochastic integer between 1 and $M - 1$.
(2) Another stochastic integer between *position*1 and M is the second cross point.

Therefore the two points divide the chromosome into three parts, i.e. Head, Body and Tail. The chromosomes' crossbar transition occurs in Body which is between them. The gene segment Bodyl in the first chromosome's Body is found in the second one. They are arranged in the second chromosome's numerical order and form a new gene segment Bodyl_new. Having removed the gene segment body and inserted gene segment Bodyl_new, the first chromosome constitutes a new one. A second new chromosome is generated in the same way.

In order to speed up the convergence, law of competition is applied in this paper. Namely compared with the fitness value of progeny chromosome and paternal chromosome, a chromosome which has higher value enters into a new population.

51.4.7 Mutation Operator

Mutation is a genetic operator that alters one or more gene values in a chromosome from its initial state under certain mutation probability P_m and then generating a new one. Law of competition is applied in this paper. In the precedence relation table, the gene segment lying in the front of the mutation point is removed, and then a feasible gene segment is formed according to the method of generating the initial solution. Combining both of them, a new chromosome was generated.

51.5 Simulation Results

Some parameters are set as follows:

pop_size is 40, crossover probability P_c is 0.8, mutation probability P_m is 0.2, *Generation_no* is 100. Getting the optimal workstation equilibrium index and demand index optimization scheme by compiling genetic algorithm program in MATLAB 7 as shown in Table 51.4, evolutionary convergence curve of GA are shown in Fig. 51.4.

51.6 Conclusions

This paper studies DLBP under uncertain cycle time, presents a multi-objective mathematic model aiming to minimize equilibrium index and demand index and resolved by GA. We design a unique chromosome decoding rule to determine

Table 51.4 The optimal balancing scheme using GA $(CT = 12)$

Workstation number	S_k	Workstation time	Equilibrium index	Demand index
1	$\{8, 10, 11, 9\}$	12	0	270
2	$\{13, 2, 3\}$	10	4	560
3	$\{6, 5\}$	12	0	465
4	$\{7, 0, 1, 4, 12\}$	11	1	1308
Total	–	45	5	2603

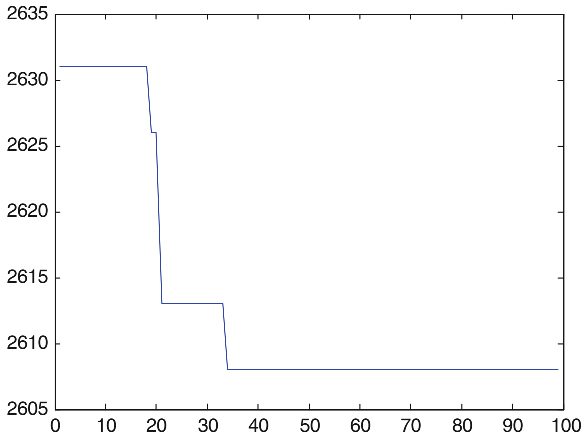

Fig. 51.4 Evolutionary convergence curve of workstation equilibrium index and demand index solved by GA

cycle time of disassembly line. On the determination of $CT(WS)$, we present a new decoding method and improve the disassembly line balancing efficiency more; in operator designing, we design a GA operator based on precedence matrix which can convert iterative procedure to matrix operation and has a good adaptability to target function. So this algorithm has faster convergence speed, and can quickly obtain the optimal solution. The simulation experiment results show the effectiveness of the algorithm.

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Chapter 52
Research on Just in Time Plan of High-Tech Products Based on Uncertain Delivery Period

Li-sha Yue

Abstract Taking some practical problems that the single-piece production of high-tech products have delivery uncertainty and the dynamic nature of product resources demand into account, this study proposes the basic hypotheses and builds double target model with maximizing customers satisfaction and earliness and tardiness minimum total penalty, and uses the branch and bound method of 0–1 programming to solve the question in order to obtain the optimal just in time plan and optimal objective function value, it can provide a reference value for just in time of delivery uncertainty enterprises with high-tech products.

Keywords High-tech products · Just in time · Plan · Uncertain delivery

52.1 Introduction

Just in time is the core of the traditional lean production, which is controlled in logistics trigger and work-in-process inventory level by kanban (Che et al. 2009). In implementation process of Kanban, the production plan of the end product is the only production indicates, various processes adopt the series production order. Products are made by next procedure pulling forward procedure according to the demand order. Only when next process has received kanban instruction, material is taken timely by last process, which also does it so. The flow of demand information transfers ahead with series type in all process by kanban, however logistics is diametric, which flows to the end product from first process of production in accordance with needs of next process, as is named "necessary parts are made in necessary time according to necessary numbers". Eventually products have been

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given to users on time by time of the orders. At present most traditional JIT planning model of lean production is built in conditions of the on-time delivery products (Jin et al. 2011; Wang 1996).

High-tech products are very different from the traditional origin products of lean production. High-tech enterprises often frequently develop new products and obsolete old products. Lean production is difficult to adapt to the frequent introduction of the new products because of the need for all components and parts of frequent introduction of kanban. There may be, some kanbans that are added to the system because of the production of a product, but this product is no longer being produced for a long time, which results in work in process will not need to be preserved (Guan and Ren 2011).

Despite on time production and on time delivery becomes the essential conditions of enterprises win in market competition, but with market economy in-depth development and various conditions limit, some products more meet the features of single pieces production because of all kinds of products types and structure complexity and more long manufacturing cycle of high-tech products manufacturing according to order contract, at the same time single pieces production is implemented, there are usually subjective wishes for the products delivery period that production enterprise and customer common have confirmed, and the products delivery period is usually specified for a period of time (Guan and Ren 2011; Wang et al. 1998). Therefore, delivery of high-tech products is usually an uncertain period. Past literature research on uncertain delivery period has regarded processing capacity as a fixed and unchanging capacity (Wang 1995; Udit 2003), as is known the stand-alone or parallel machines, while variable abilities of balance are not considered, so these methods cannot be used to a real master production scheduling in manufacturing system (Wang et al. 1998; Warneeke and Huser 1995; Askin and Goldberg 2002), and they can not apply to high-tech products manufacturing system. So, from this significance, it has real significance and theory value for covering the shortage of relevant theory research on high-tech products manufacturing. When delivery period is for uncertain conditions, how enterprises that implement single pieces production draw up JIT plan so that JIT plan algorithm built is fit for high-tech products manufacturing enterprises and practice.

52.2 Basic Hypothesis

Hypothesis 1 Many customers provide orders in order to produce K high-tech products. Among this case, m indicates the production processes, R_i indicates the production cycle of the ith product, A_{ij} indicates production capacity of the jth process of the ith product, M_j indicates the maximum productive capacity of the jth process, $i = 1,2,\ldots,k$; $j = 1,2, \ldots,m$.

Hypothesis 2 The delivery period required of the ith product is $[e_i, f_i]$ for the product contract of customer order, the customer will be most satisfied with the product during the delivery period, $[E_i, F_i]$ indicates the delivery period window of the ith product, usually meeting: $[e_i, f_i] \in [E_i, F_i]$. The earliest start time of the ith product that is allowed is S_i, and $i = 1, 2\ldots k$.

Hypothesis 3 The product delivery outside the stipulated delivery period will be punished, and the reward amount of a day in advance and punishment amount of a day later are $W_i/100$ in accordance with the contract, W_i indicates the total contract price of the i product, $i = 1,2,\ldots,k$.

52.3 Model Building

Definition model variable $x_i(t) = 1$ which represents the delivery products of the t point-in -time of the i product, otherwise $x_i(t) = 0$, $i = 1,2,\ldots,k$.

To illustrate the problem, the subordinate function $\mu_i(t)$ of satisfaction is given. The function represents customer satisfaction in the delivery products of the t point-in-time of the i product, as shown in Fig. 52.1.

So giving subordinate function $\mu_i(t)$ expression, as follows:

$$\mu_i(t) = \begin{cases} 0 & t \le E_i, t \ge F_i \\ \frac{(t-E_i)}{e_i-E_i} & E_i < t < e_i \\ \frac{(F_i-t)}{F_i-f_i} & f_i < t < F_i \end{cases} \tag{52.1}$$

The products of high-tech enterprises satisfy customers as well as the minimum total penalty of tardiness and lead time, so it is a problem of multi-objective function.

A goal is customer satisfaction, and another goal is the minimum total penalty of tardiness and lead time. For the former, customer satisfaction of the i product is as follows:

$$\mu_i(tx_i(t)) = \sum_{t=E_i}^{e_i} \frac{(t-E_i)x_i(t)}{e_i - E_i} + \sum_{i=e_i}^{f_i} x_i(t) + \sum_{t=f_i}^{F_i} \frac{(F_i - t)x_i(t)}{F_i - f_i} \tag{52.2}$$

Supposing δ indicates level of customer satisfaction, and there is:

$$\delta = \min \mu_i(tx_i(t)) \tag{52.3}$$

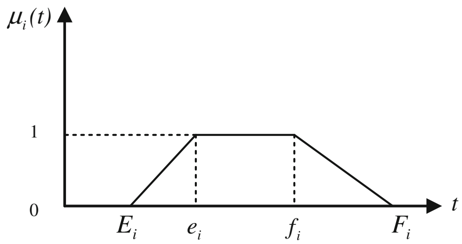

Fig. 52.1 Subordinate function figure of customer satisfaction of the delivery time of products

For the latter, Supposing that $M(x_i(t))$ indicates the total penalty of tardiness and lead time, then building the penalty model of tardiness and lead time is as follows:

$$\min_{x_i(t)} M(x_i(t)) = \sum_{i=1}^{k}\left[W_i \Big/ 100\left(\sum_{t=1}^{E_i}(E_i - t)x_i(t) + \sum_{i=F_i}^{T}(t - F_i)x_i(t)\right)\right] \tag{52.4}$$

From the producers point, they hope to manufacture the products of customer satisfaction under the condition of the multi-product, and the minimum total penalty of tardiness and lead time that are beyond the contract delivery period window.

Supposing $\varpi(x_i(t))$ is the objective function under the conditions, and building function (MBH) is as follows:

(MBH)

$$\begin{aligned}\max_{x_i(t)} \varpi_i(t) &= \delta - M(x_i(t)) \\ &= \delta - \sum_{i=1}^{k}\left[W_i \Big/ 100\left(\sum_{t=1}^{E_i}(E_i - t)x_i(t) + \sum_{i=F_i}^{T}(t - F)_i x_i(t)\right)\right]\end{aligned}$$

s. t.

$$\begin{array}{lll} \displaystyle\sum_{t=E_i}^{e_i}\frac{(t-E_i)x_i(t)}{e_i - E_i} + \sum_{t=e_i}^{f_i}x_i(t) + \sum_{t=f_i}^{F_i}\frac{(F_i - t)x_i(t)}{F_i - f_i} \geq \delta & & i = 1,2,\cdots,k \\ \displaystyle\sum_{t=1}^{T}x_i(t) = 1 & & i = 1,2,\cdots,k \\ \displaystyle\sum_{i=1}^{k}\sum_{h=t}^{t+R_i}A_{ij}x_i(h) \leq M_j & i = 1,2,\cdots,k; & j = 1,2,\cdots,m \\ \displaystyle\sum_{t=1}^{T}tx_i(t) \geq S_i + R_i & & i = 1,2,\cdots,k \\ x_i(t) = 0 \ \text{or} \ 1, & i = 1,2,\cdots,k; & t = 1,2,\cdots,T \end{array} \tag{52.5}$$

The model above shows that the delivery period belongs to the uncertain fuzzy delivery period which has double goals of the maximum customer satisfaction and the minimum total penalty of tardiness and lead time. The model becomes the single-variable linear mixed 0–1 programming problem, so the solution of the model can easily be obtained (Ishibuchi et al. 1994).

52.4 Model Solution Flow Chart

The model solution flow chart is shown as Fig. 52.2.

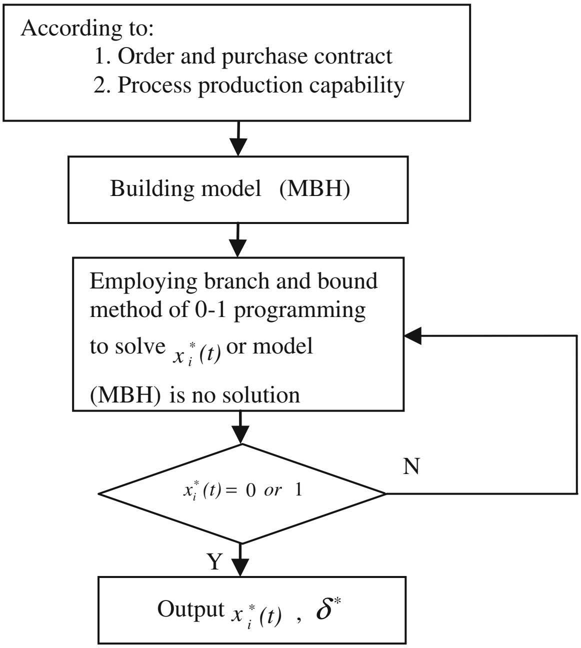

Fig. 52.2 Model solution flow chart

52.5 Calculation Example

A high-tech manufacturing enterprise will produce four kinds of products in the plan period (Che et al. 2009; Kramer and Lee 1994); the production of each product must pass two processes. The penalty that has been agreed on a day in advance or tardiness in the contract is 1 % of the contract amount. The production cycle, the earliest allowed start date for each product and its capacity demands of the *j*th step in the manufacturing cycle are listed in Table 52.1. The maximum production capacity of process is shown in Table 52.2. Customer contract as well as JIT plan that the FORTRAN programming compiles is shown in Table 52.3.

Table 52.1 Each product cycle, the earliest allowed start time of production for each product and product of capacity needs of process *j* in the manufacturing cycle

Product i	Cycle R_i	Earliest allowed start time S_i	$j/A_{ij}/R_i$	3	2	1
1	2	1	1		5	3
			2		4	4
2	2	2	1		3	2
			2		4	6
3	3	2	1	3	2	3
			2	4	3	3
4	2	1	1		2	5
			2		3	4

Table 52.2 The maximum production capacity of process

j/t	1	2	3	4	5	6	7
1	10	12	10	12	12	10	10
2	13	13	12	13	12	12	12

Table 52.3 Customer contract and JIT plan

Contract						Calculation result
Product i	W_i	E_i	e_i	f_i	F_i	Plan time interval of production
1	3000	3	5	8	10	5, 6
2	4000	4	6	9	10	5, 6
3	3700	4	5	8	9	6, 7, 8
4	5000	3	6	8	12	5, 6
Objective function values						$\delta^* = 0.677$ $\varpi(x_i(t)) = 0.677$

52.6 Conclusion

Past research literatures on uncertain delivery period usually have been conducted in consistent conditions of delivery period and window period. If the delivery period and window period are inconsistent, the tardiness period problem of punishment is mainly studied. This study aims at high-tech products of single pieces as research object based on related literatures, which expands the more general inconsistent situation of delivery period and window period. The JIT plan is obtained in the foundation of production capacity balance by building model and using dynamic 0–1 programming method. The JIT plan has taken into account some more realistic problems such as the uncertainties of the delivery period and the dynamic nature of the resource requirements, therefore, this research is more realistic than relevant research before, and it can provide reference values for implementing JIT of a high-tech manufacturing enterprise.

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Chapter 53
Research on Milk-Run Routing Problem of Automotive Supply Logistics Based on Genetic Algorithm

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Abstract Vehicle routing problem is one of the hot topics that most domestic and foreign researchers, transport schemes makers and managers greatly concerned over the past decade. The genetic algorithm is a global search stochastic algorithm based on the principle of natural evolution, which is widely used and played an important role in the location, distribution, scheduling, transportation and layout planning. In this paper, based on the analysis of existed low loading efficiency of milk-run in an independent car manufacturer enterprise in China, the optimization mathematical model was established, and the path planning was optimized by the use of genetic algorithms. Through case studies, the validity of the model algorithm was verified and the resulting optimization results exerted an important guiding significance on the improvement of business milk-run running to improve the logistics management level, reduce logistics costs and enhance their market competitiveness.

Keywords Automobile supply logistics · Milk-run · Vehicle routing problem (VRP) · Genetic algorithm

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53.1 Introduction

In the automotive supply chain system made up of supply logistics, production logistics and distribution logistics, supply logistics is the source of the entire automotive supply chain and the most complex part involving hundreds of parts suppliers and thousands of parts. The key to improve the operational efficiency of supply logistics depends on choosing which kind of logistics mode to achieve the transportation scheduling. The trucks taken by mile-run method is: the assigned carriers from the vehicle manufacturing plant take the vehicles out of the suppliers in accordance with the designed path within a specified time window, meanwhile transport those empty containers from the vehicle manufacturing plant to the supplier in turn. Milk-run refers to the pickup mode of small quantity, frequency, in-time pickup and the closed-loop pull kind, which contains the advantages of reducing inventory, improving vehicle loading efficiency and logistics operational efficiency of transport quality, reducing transportation costs and the disposable packaging costs under the original mode of delivery to play an important role in reducing the cost of the entire automotive supply chain. Nowadays, milk-run logistics model has been operated maturely in foreign countries, as to many car manufacturers, such as Guangzhou Toyota, Tianjin Toyota, Shanghai Volkswagen, Shanghai GM, FAW Fengyue, milk-run has developed into an effective JIT-automotive supply logistics model (Wang et al. 2010).

As to the study of milk-run in foreign countries, it is mainly reflected through two aspects: the management mode and operation mode of the automotive supply logistics. One of the key factors to determine the successful implementation of Milk run mode is the arrangement of vehicle routing arrangements. Reasonable arrangements of the path are better to save time, to reduce the transport costs and to improve operational efficiency and quality of the automotive supply logistics. Domestic scholars put forward a lot of exact algorithms and heuristic algorithms for the VRP, such as Clarke and Wright (1964) used savings algorithm for solving the vehicle routing problem from different angles with the literature as well as in the literature (Bodin et al. 1983; Ball et al. 1995; Toth and Vigo 2002). Domestic researches of VRP started lately but it recently develop rapidly, for instance, the Professor Guo Yaohuang from Southwest Jiaotong University has done a series of studies of this kind of problem since 1989 and had published the first book "Optimized scheduling of vehicles". A detailed study of vehicles scheduling theory different constraints, stochastic and dynamic VRP solving model and algorithm has been done in literature (Toth and Vigo 2002; Li and Guo 2001; Zheng and Cheng 2010; Guo and Xie 2003; Swihart and Papastavrou 1999; Wang et al. 2007). However, many domestic enterprises' understanding and adoption of the VRP is still in its infancy, a lot of time, personnel and funding needs and more scientific, comprehensive planning are required.

Table 53.1 Original program of milk-run in local suppliers

Route	The number of suppliers	Suppliers amount	Subsidiary region	Lenth of vehicle (m)	Quantity of vehicle invested	Circles	Circle time (H)
GX01	3	3	Industries development zone	12.36	2	4	2
GX02	2	2		7.85	3	8	1
GX03	3	3		12.36	2	4	4
GX04	5	5		12.36	1	2	2
CG01	4	4	Chaoyang industrial park	12.36	2	4	2
JK01	5	4	Economic and technical development zone	12.36	2	4	2

53.2 Background and Purpose of This Study

Some independent car manufacturer had started planning milk-run of 123 kinds of new plant and 22 local suppliers of parts, the first step is parts screening, that is calculating the daily volume in accordance with production plan, setting the pickup frequency or period, and then investigate the suppliers and logistics path, draw the map and road map of the Milk-run supplier according to the convenient transportation, then after a theoretical setting, the actual operation of testing and adjustment etc., logistics schedules was made. The logistics planning scheme is as shown in Table 53.1. But the original program depends mainly on the technical staff's learning from industry experience, the intuitive judgment and the division of the vehicle path is founded in accordance with the principle of manufacturers locating in proximate area. Due to the lack of optimization analysis of initial program developing and path planning, there are some problems such as the low (40–60 %) freight vehicle stowage, and higher logistics costs after more than a year's running.

Based on the above thinking, we analyzed the original program and studied its optimization in native Changchun: (1) to determine the optimization objectives: reasonable arrangements for the pick path, saving time, reducing transportation costs, improving operational efficiency and quality of the automotive supply logistics. (2) by the use of logistics engineering, operations research, computer science, optimized program aiming at the VRP problem solving has been worked out.

53.3 VRP Theoretical Model and the Solving Genetic Algorithm

The VRP model of this enterprise can be described as: in a system of supply and demand relationship, there are a vehicle manufacturing plant, a transportation provider, a number of transport vehicles and several parts suppliers. Transportation provider assign a number of carriers to get goods from multiple auto parts suppliers, and then return to vehicle production plant, go back to the transportation company after delivery. Each supplier's location and time window of pickup are stable; per vehicle carrying capacity and load capacity are stable too. It is required that reasonable arrangements for the travel path and travel time of vehicle pickup should be achieved in order to minimize the total cost.

Prerequisite assumptions of VRP theoretical model:

1. Fixed costs of each vehicle of one model is the same, yet variable costs is proportional to the distance, the distance is related to each cycle time, therefore if the cycle time is longer, the cost is higher, so the objective function is directly showed that total cycle time is minimum;
2. An average speed of per vehicle traveling is the same, without considering the impact of traffic conditions;
3. Only two kinds of vehicle specifications for milk-run in motor vehicle manufacturer;
4. Parts loading time is fixed;
5. There is enough available vehicles in automobile factory;
6. Auto parts obtained from the suppliers can be transported with the car;
7. Parts suppliers have prepared goods within the specified time window.

Meanwhile the following constraints should be satisfied:

1. Total number of parts from the suppliers on each pick path is no more than the pickup vehicle's carrying capacity and load capacity;
2. The volume to take must be met in every supplier, and only one car take the goods;
3. Vehicles start from the logistics center, ultimately return to the car factory and then return to the logistics center;
4. Each car must arrive at the supplier to get the goods within the specified time window, otherwise invalid.

In the automotive supply logistics milk-run mode, the motor vehicle manufacturer fixed the time for taking goods in every parts supplier in order to ensure an adequate supply of raw materials in vehicle manufacturing plant and to meet the production plan to prevent the production line from undergoing downtime. If the parts suppliers hadn't prepared the parts within the specified time window, the pickup vehicle would directly go to the next parts suppliers to take goods instead of waiting for its delivery. The supplier who hadn't delivered parts in time should directly delivery to the enterprise or compensate the losses caused by out of stock of the enterprise, in this paper, the optimization calculations assume that the supplier have prepared goods well within the specified time window, so the main consideration of the path arrangements is whether the vehicle can reach the parts suppliers in specified time window.

The genetic algorithm is a probability optimization method of stimulate biological evolution and genetic variation mechanisms. The basic idea is derived from Darwinian evolution and Mendelian genetics, that is to say heredity and variation play an important role in biological evolution, it not only makes biology maintain the inherent characteristics, but also can change itself to adapt to the new living environment. Since the genetic algorithm does not require the optimized object is continuous and differentiable, and has strong robustness and inherent parallelism to find satisfactory solution for the large-scale optimization object within the time allowed, so it is suitable for complexity of multi-extremal optimization and combinatorial optimization problems in non-convex space, and has been widely used in adaptive control, machine learning, electrical, automation and artificial life. Biological evolution is a group form; the object of genetic algorithm is also a group. It will make candidate solution of problems encoded into the chromosome to form a collection of N chromosomes. Through simulating biological process of evolution, it s elect chromosomes which can be adapt to the environment to do the selection, crossover and mutation operations in order to elect offspring chromosome which is better adapt to the environment, and finally converge those chromosome being adapt mostly to the environment until the optimal solution of the problem. The genetic algorithm computation process can be described as follow (Fig. 53.1).

53.4 Model Parameter Settings and Optimization Solution

53.4.1 Model Parameters are Set as Follows

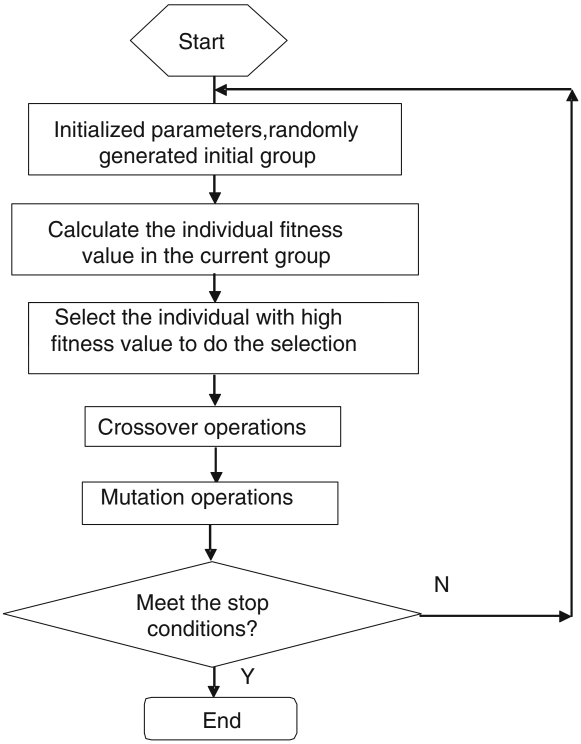
$$X_{ijk} = \{T_0 + T_1 + T_2 + T_3 + T_4 + T_5 + T_6 + T_7 + T_8\} \tag{53.1}$$

$$T = n_1 \cdot r_1 + (n_2 + a) \cdot r_2 \tag{53.2}$$

Among them, T_0 is the receive car sequence information and print board time; T_1 is the prepare goods time(material confirm and prepare time); T_2 is the total loading time of each supplier; T_3 is the total time run along the Milk-run transportation supply route; T_4 is the discharge, acceptance and storage time; T_5 is the schedule progress lane storage time (i.e. buffer time); T_6 is the security time of abnormal progress lane correspondence; T_7 is offline separating packing time; T_8 is the transport time to supply line side; n_1 is the number of coating workstation, n_2 is the assembly depth, namely the location or project where parts are in the process arrangement. For example, the project depth of the first location is 1, then rank in order. The depth of offline separating packing line is backward calculated according to the depth assembly into the final assembly line after offline separating packing; a is the body reserve number between coating referrals point and assembly top thread point; r_1 is the tact time of coating line, r_2 is the tact time of final assembly line.

If suppliers $L/T \leq T$, implementation conditions of Milk-run are satisfied. Otherwise, consider other logistics mode. According to the experience of some auto manufacturing companies, within 100 km, Milk-run requires at least six hours

Fig. 53.1 Computing flow chart of genetic algorithm



lead time for the third logistics providers, which means that automakers should hand the order over to the third logistics company for at least 6 h ahead of time to ensure timely delivery.

53.4.2 Selection in Milk-Run Logistics Mode

For some automaker, at first, select suppliers within a certain radius in the urban or suburban, then statistic and determine materials quantity demand. Based on the part type (part size, packing ways using racks or boxes), calculate single cargo quantity respectively, whether the suppliers delivering by themselves can make trucks full load, if so, this logistics mode can be used, then select such suppliers after one by one confirmation.

If the transportation is in the local city or suburb, and single cargo quantity is too small to make trucks full load, it's better to consider using Milk-run mode for goods collection. Firstly, screen such parts and calculate daily goods to set the frequency or cycle of goods collection. Then, assess suppliers and logistics route on the ground, including traffic convenience and regional logistics flow, to decide the Milk-run logistics routes. After confirmation, draw the Milk-run suppliers map and routes map. If a line is calculated a very small amount of single demand volume and load rate is less than 60 %, suppliers can deliver separately to the re-distribution center. Then according to materials demand information in the automakers, re-distribution center can choose the short distance, high frequency, small batch and unified supply logistics mode.

53.4.3 Milk-Run Logistics Route Planning

In the design process of Milk-run, the primary thing is to collect and analyze information to determine the basic distribution area. Based on the information of the production plan in automakers, the needed parts type, type number, quantity, transport capacity, supply and demand balance and the geographical location of suppliers, the frequency, transport vehicle type and quantity, taking order and routes can be determined. Simple Milk-run transportation problems can obtain optimal solutions by observation and simply calculation with excel calculation. For the complex transportation problems, it needs to establish a transportation planning model by considering the transport way selection, transportation route design, mix load design, vehicle demand quantity calculation, delivering time arrangement and distribution performance analysis and so on. For most independent auto manufacturing company, logistics route planning is a balance transport problem between the total supply and the total demand. Its transport system has m source nodes (many suppliers) and n destination nodes (many unloading points). When establishing the auto parts Milk-run direct sending system programming model, it is needed to solve the problem that realizes the minimum transportation expenses under the condition of maximum vehicle load rate. This paper solves this problem by mathematical method and use operation software like *ORS*, *SPSS*, *E-views* or *SAS* to calculate.

Auto parts Milk-run direct sending issue is close to the balance transportation problem, therefore, model is established as follows: m source nodes supply $a_i(i = 1, 2, \cdots m)$ for parts; the demand quantity of n destination nodes for this parts is b_j $(j = 1, 2, \ldots, n)$; The piece volume of unit parts transported from the i source node to the j destination node is c_{ij}. Suppose x_{ij} is the number of parts transported from the i node to the j destination node, d_{jz} is the largest loads, V is the total transport volume. Mathematical model can be established as (53.3) and (53.4).

Objective function:

$$\max V = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij} \tag{53.3}$$

Constraint condition:

$$\text{s.t.}\quad \begin{cases} \sum_{j=1}^{n} {}_{ij} = a_i & i = 1, 2, \cdots, m \\ \sum_{i=1}^{m} x_{ij} = {}_j & j = 1, 2, \cdots, n \\ 0 \le \sum_{i=1}^{m} \sum_{j=1}^{n} {}_{ij} x_{ij} \le {}_{jz} & i = 1, 2, \cdots m;\ j = 1, 2, \cdots, n;\ z = 1, 2, \cdots, t \end{cases} \tag{53.4}$$

Among them: $\sum_{i=1}^{m} a_{ij} = \sum_{j=1}^{n} b_{ij}$

Auto parts Milk-run direct sending system is not only to solve the maximum load rate problem, but also to solve the shortest route problem, thus another model is established: suppose A_{ij} is the transportation volume of the i parts on the j vehicle (Generally the parts total weight is no more than the vehicle total weight, so parts volume determine the transportation volume and vehicles quantity), B_j is the maximum loading volume of the transport vehicles (maximum transportation volume), suppose D_{kj} is the transport distance of the j vehicle on the k route, a linear programming model is established as follows:

Objective function:

Min C = transportation expenses

$$\text{namely: Min C} = A_{ij} \cdot D_{kj} \tag{53.5}$$

Constraint condition:

$$\text{s.t.} \sum A_{ij} \le B_j \tag{53.6}$$

After the data analysis and the actual survey for regional routes, software is used to solve the model.

53.4.4 Compile Milk-Run Logistics Timetable and Calculate Vehicle Number Needed

For enterprises applying Toyota lean logistics, the premise of implementing Milk-run

Table 53.2 The optimization program of milk-run pickup of local suppliers

Route	The number of suppliers	Suppliers amount	Length of vehicle (m)	Quantity of vehicle invested	Circles	Circle time (H)
GX01	8	3	12.36	2	2	4
GX02	2	2	12.36	1	2	4
GX03	4	3	12.36	2	2	4
GX04	2	5	12.36	3	8	1
CG01	6	4	7.85	2	2	4

53.5 Effects and Conclusions of the Applied Model Algorithm

The final results were obtained by using a genetic algorithm after many rounds of calculations on the above models. The optimization program was shown in Table 53.2.

Compared with the initial value in the original programs, the carts reduced from 9 to 8, saving one. Cars reduced from three to two, saving one. The occupied discharge spaces reduced from three to two, saving a discharge space. The results show that the model and algorithms in this paper make the milk run planning program optimization more reasonable, which cannot be done by human labor.

Further design of the model algorithm software input/output interface will greatly reduce the work intensity and difficulty of logistics management personnel, and can further integrate the logistics-related data, it is also beneficial to enterprises establish a unified information platform and database to get progress in the construction of enterprise digital, so that managers can freed from the heavy computational and statistical work, and devote the main energy into the improvement of new projects and technology.

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Chapter 54
Research on Modeling and Optimization Algorithm for Hot Rolling Batch Planning of DHCR Production

Duo Shan, An-jun Xu, Yong-ming Lu and Hong-bing Wang

Abstract A high rate of direct hot charge (DHCR) in steel production has significant benefits, such as cost reduction, improved productivity. However, scheduling DHCR rolling sequence is a daunting task because it requires temporal synchronization and sequence consistency between continuous caster and hot rolling production schedule. This paper proposed "a consistency factor of the planning sequence" in order to coordinate the casting production plan with hot rolling production plan. Then, an optimization model of hot rolling batch planning so as to improve DHCR proportion was established based on integrated production of steelmaking-continuous casting-hot rolling. The model was solved by a modified genetic algorithm—HGA.

Keywords Direct hot charge · Genetic algorithm · Hot rolling batch planning · Integrated production

54.1 Introduction

Iron and steel industry is an important basic industry providing the primary materials for automobile, shipbuilding, aviation, construction and other industries. But the steel industry faces increasing competitive challenges. Against the

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background of increased costs and reduced revenues, steel industries have had to drastically cut costs whilst improving product quality and customer focus. To cut cost and save energy consumption in production process from hot steel to coil, some techniques such as continuous casting-direct hot charge rolling (CC-DHCR) have been proposed. CC-DHCR is an integration production mode of the continuous caster and the hot strip mill in steel production, in which the hot slabs coming from the continuous caster are directly charged into the heat furnaces, and then hot rolling process is undertaken.

The coordination between batch plans in steelmaking-continuous casting and hot rolling batch planning significantly influences the process of hot charge and hot delivery, because the restraints are different in the integrated steelmaking, continuous casting and rolling process. More details of the model and optimization algorithm development in hot rolling planning can be found in (Lopez et al. 1998; Tang et al. 2000; Chen et al. 1998, 2006; Zhang et al. 2000; Li et al. 2000). The paper (Tian et al. 2004; Sun et al. 2000; Ma et al. 2005; Li et al. 2007; Tang et al. 2001) discussed the hot rolling batch planning in the integration production. And the paper (Lv and Xu 2002; Xu et al. 2005) analyzed the hot charge and hot delivery. (Lu et al. 2011) introduced the coordination for the sequence of slabs getting out from continuous casting machine and entering into roller, which used stationary production rhythm as the penalty coefficient. The rhythm of production would be changed with casting speed, rolling time and other factors, so the model is no longer satisfied with production practice. This paper proposes "a consistency factor of the planning sequence" originally for coordinating the casting production plan with hot rolling production plan in order to increase the ratio of DHCR in hot rolling batch planning based on the integrated production.

54.2 Consistency Factor of Planning Sequence

Recently, the main factors effecting DHCR are included as follows:

(1) Disturbance in the process of production
Slabs of DHCR are directly sent into reheating furnaces without buffering in slab yard. It is possible that the integrated production of DHCR is abnormal when the disturbance such as time fluctuation, the problems of smelting technology and production, and equipment fault comes up. These special cases can be reduced and even avoided through the scientific management.

(2) Batch planning
Planning of DHCR is not only hot rolling planning but also steelmaking planning. The former mainly focuses on the specification of slabs; the latter mainly focuses on the composition of liquid steel. DHCR planning takes the width and the gauge of slabs into consideration when the planning of steelmaking and continuous casting is being formed. Furthermore, the sequence of

slabs getting out from continuous casting machine and the sequence of rolling should keep consistent, which is helpful to improve the ratio of DHCR.

(3) Production scheduling
The optimization scheduling of reheating furnaces can increase the ratio of hot charge and hot delivery and the ratio of DHCR in integrated scheduling of steelmaking, continuous casting and hot rolling to some extent. But the number of reheating furnace is limited and the slabs in every furnace are queued in the rule of FIFO. At the same time, if slabs stayed in furnaces for too much time, it would cause loss of metal for the formation of oxide scale and energy consumption. Therefore, collaboration of planning scheduling with batch planning can efficiently improve the ratio of hot charge and hot delivery and the ratio of DHCR.

This article mainly focuses on coordinating the sequence of slabs getting out from continuous casting machine with the sequence of rolling as far as possible in integrated production planning, in order to improve the ratio of DHCR.

54.2.1 DHCR and HCR Planning

The consistency factor of the planning sequence is defined as whether the sequence of slabs getting out from continuous casting machine coordinates the sequence of rolling, which characters its coordination degree. Assuming α_i as the coordination factor, when $\alpha_i = 1$, it means that slab i can't need to wait for other slabs being rolled and it meets with certain conditions of direct hot charge.

For DHCR and HCR planning, assuming C_p is the sequence of slabs getting out from continuous casting machine and R_p is the sequence of rolling. φ_i is the cluster of slabs before slab i is rolled. δ is the latest slab getting out from continuous casting machine among φ_i. $C_p(i)$ is the sequence number of slab i getting out from continuous casting machine. $R_p(i)$ is the sequence number of slab i being rolled. Then:

$$\alpha_i = \begin{cases} 1, & C_p(i) > C_p(\delta) \text{ and } R_p(i) - R_p(\delta) = 1 \\ 0, & \text{otherwise} \end{cases} \tag{54.1}$$

For example, there are ten slabs: $p1, p2, p3, p4, p5, p6, p7, p8, p9, p10$,
$CC_{seq} : p1, p2, p3, p4, p5, p6, p7, p8, p9, p10$,
$Roll_{seq} : p2, p4, p7, p10, p3, p6, p8, p1, p5, p9$.

When slab $i = p8$, $\varphi_{p8} = \{p2, p4, p7, p10, p3, p6\}$, $\delta = p10$, $CC_{seq}(p8) = 8$, $CC_{seq}(p10) = 10$, $Roll_{seq}(p8) = 7$, $Roll_{seq}(p10) = 4$, $CC_{seq}(p8) < CC_{seq}(p10)$, $Roll_{seq}(p8) - Roll_{seq}(p10) = 7 - 4 = 3$. So when slab $p8$ gets out from continuous casting machine, $p8$ needs to wait for the slab $p10$ getting out from continuous casting machine and rolling $p10$, $p3$, $p6$. On this account, $p8$ has not meet with the sequence of DHCR, $\alpha_{p8} = 0$.

When slab $i = p7$, $\varphi_{p8} = \{p2, p4\}$, $\delta = p4$, $CC_{seq}(p7) = 7$, $CC_{seq}(p4) = 4$, $Roll_{seq}(p7) = 3$, $Roll_{seq}(p4) = 2.CC_{seq}(p7) > CC_{seq}(p4)$, $Roll_{seq}(p7) - Roll_{seq}(p4) = 3 - 2 = 1$, so slab $p7$ getting out from continuous casting machine is rolled after the slab $p4$, and $p7$ has meet with the sequence of DHCR, $\alpha_{p7} = 1$.

54.2.2 CCR Planning

For CCR planning, when slab i is cold, $\alpha_i = 0$. Assuming H is the cluster of slabs from DHCR and HCR planning, then the consistency factor of the sequence α_i:

$$\alpha_i = \begin{cases} 1, & C_p(i) > C_p(\delta) \text{ and } R_p(i) - R_p(\delta) = 1 \text{ and } i \in H \\ 0, & \text{otherwise} \end{cases} \tag{54.2}$$

54.3 Model and Algorithm of Hot Rolling Batch Planning

Hot rolling planning can be described as follows. A large number of slabs are first arranged into a series of rolling units. There are warm-up material stages and staple material stages. Staple materials are the major part and the main production stages of the rolling unit, so this paper mainly studies the staple materials. The objective of the planning stage is to minimum the hot rolling unit, the fare caused by the fluctuation of width, gauge and hardness, and coordinating the sequence of slabs getting out from continuous casting machine and hot rolling.

54.3.1 Planning Model

The mathematic model of hot rolling batch planning is described as:

$$Min \quad M \tag{54.3}$$

$$Min \quad E = \sum_{k=1}^{M} \sum_{i=1}^{N} \sum_{j=1}^{N} C(ijk) \tag{54.4}$$

$$Max \quad S = \sum_{i=1}^{N} \alpha_i \tag{54.5}$$

where, $C(ijk) = \left(P_{ij}^W + P_{ij}^D + P_{ij}^H\right) X_{ijk}$.

s.t.:

$$\sum_{i=1}^{N} (q_{ik} \times L_i) \le L_{\max}, k \in \{1,2,3\ldots M\}, \tag{54.6}$$

$$\begin{aligned} 0 \le X_{ijk} \times (W_i - W_j) \le W_{\max} \\ i,j \in \{1,2,3\ldots N\}, k \in \{1,2,3\ldots M\} \end{aligned} \tag{54.7}$$

$$\begin{aligned} X_{ijk} \times |D_i - D_j| \le D_{\max} \\ i,j \in \{1,2,3\ldots N\}, k \in \{1,2,3\ldots M\} \end{aligned} \tag{54.8}$$

$$\begin{aligned} X_{ijk} \times |H_i - H_j| \le H_{\max} \\ i,j \in \{1,2,3\ldots N\}, k \in \{1,2,3\ldots M\} \end{aligned} \tag{54.9}$$

$$\begin{aligned} \sum_{j \in \theta_{ik}} Z_{ijk} L_j \le l_{\max} \\ i \in \{1,2,3\ldots N\} \end{aligned} \tag{54.10}$$

$$\sum_{i=1}^{N} q_{ik} \le 1, \quad k \in \{1,2,3\ldots M\} \tag{54.11}$$

where N is the amount of slabs; M is the number of rolling unit; W_i is the width of slab i; D_i is the gauge of slab i; H_i is the hardness of slab i; L_i is the length of slab i; $L_{\max}$ is the maximum total length of the slabs rolled in one unit; $W_{\max}$ is the maximum width difference of the two neighboring slabs rolled in one unit; $D_{\max}$ is the maximum gauge difference of the two neighboring slabs rolled in one unit; $H_{\max}$ is the maximum hardness difference of the two neighboring slabs rolled in one unit; $l_{\max}$ is the length limitation of slabs continuous rolled with the same width in one unit; θ_{ik} is the cluster of slabs continuous rolled with the same width of slab i in rolling unit k; P_{ij}^{W} is the penalty coefficient of width fluctuation of neighboring slab i and j; P_{ij}^{D} is the penalty coefficient of gauge fluctuation of neighboring slab i and j; P_{ij}^{H} is the penalty coefficient of hardness fluctuation of neighboring slab i and j. Additionally, other variables are as follows:

$$X_{ijk} = \begin{cases} 1, & \text{if slab } j \text{ is after slab } i \\ & \text{and both } i \text{ and } j \text{ are in the same unit } k \\ 0, & \text{otherwise} \end{cases} \tag{54.12}$$

$$q_{ik} = \begin{cases} 1, & \text{if slab } i \text{ is in the unit } k \\ 0, & \text{otherwise} \end{cases} \tag{54.13}$$

$$Z_{ijk} = \begin{cases} 1, & \text{if slab } j \text{ is rolled after slab } i \text{ in unit } k \\ & \text{and their rolling widths are equal} \\ 0, & \text{otherwise} \end{cases} \tag{54.14}$$

Equation 54.3 is the objective function that minimizes the numbers of rolling unit. Equation 54.4 of the model is to minimize the penalty coefficient caused by the fluctuation of width, gauge and hardness in the same rolling unit. Equation 54.5 is to minimize coordination degree of rolling planning, the calculation method of which follows as Eq. 54.2. Equation 54.6 means that the total length of slabs in one unit is not more than the maximum and Eq. 54.7 means the width of two neighboring slabs decreases progressively and the fluctuation is not more than the maximum. Equations 54.8 and 54.9 ensure that the fluctuation of the gauge and the hardness for two neighboring slabs is not more than the maximum respectively in the same rolling unit. Equation 54.10 is to guarantee that the length of rolling in the same width is not more than the maximum, and Eq. 54.11 means every slab in rolling planning turns up only one time.

54.3.2 Solving Algorithm

The improved genetic algorithm which the paper (Tang 1999) introduced is adopted in this article. And the number of generations is 20, 30 individuals for each generation. Assuming I as an individual, the penalty of fluctuation is $E(I) = \sum_{k=1}^{M}\sum_{i=1}^{N}\sum_{j=1}^{N} C(ijk)$.

(1) Coding method: Coding in the code number of slabs, the slab cluster consists of N slabs, which includes M rolling units, and the sequence of slabs shows the sequence of rolling.
(2) Initializing the first generation of individuals: The initial generation includes 16 random individuals and 4 compulsory individuals arranged with the time point of slabs getting out from continuous cast machine, the width, the gauge and the hardness.
(3) Parents generation: According to the initial generation N, and matched pairs, generated the parent's pairs $P_N^2 = N(N-1)$.
(4) Fitness function: Take the reciprocal objective function as the fitness function. Because the model established is multi-objective function, the fitness function includes the sub function indicating rolling unit $f_1(I) = {}^1/_M$, and the function indicating penalty for fluctuation $f_2(I) = {}^1/_E$, and the function indicating the coordination degree of the planning sequence of continuous casting and hot rolling sequence $f_3(I) = {}^1/_S$.
(5) The determination of rolling units M and the penalty of fluctuation $E(I)$: Initially, $M = 0$, $E(I) = 0.0$, searching every individual according to the constraint, when the constraint cannot be satisfied, then $M = M + 1$, otherwise, $E(I) = E(I) + C(ijk)$.
(6) Selection: Select the individual with maximum $f_1(I)$. If $f_1(I)$of two individuals is the same value, comparing $f_2(I)$, and the bigger one is selected. Similarly, if

the $f_2(I)$of two individuals is same, then compare $f_3(I)$, and select the smaller one. Ten optimal results are selected in every process that forms the new generation and repeats.

(7) Crossover and mutation: The mutual inspiring crossover algorithm is used. One position is chosen at random in parents' series, then compares their width of slabs at chosen position, chooses the wider one, which is the center of parents' series and turns to be the first slab by right rotation, and the first slab for the first interim generation is determined. The slab with smaller $C(ijk)$ is selected after comparing the second slab in first interim generation with the first slab selected, which is the center of first interim generation and turns to be the second slab by right rotation, and the second slab for the second interim generation is determined, by analogy, the slab series of filial generation are determined through seeking all slabs. For example, the parents' series in rolling unit k are A, B:

$$A = p2 - p6 - p4 - p3 - p8 - p1 - p5 - p10 - p7 - p9,$$

$$B = p8 - p5 - p1 - p10 - p7 - p6 - p2 - p4 - p9 - p3.$$

Choose the position $\lambda = 3$ at random, $A(3) = p4, B(3) = p1$, and compare the width of slabs from the chosen position in parents series. If $width(p4) > width(p1)$, the position of $p4$ is the center of the series, and rotating the series before the chosen position. The first interim generation of A_1, B_1 shows as followed:

$$A_1 = p4 - p3 - p8 - p1 - p5 - p10 - p7 - p9 - p2 - p6,$$

$$B_1 = p4 - p9 - p3 - p8 - p5 - p1 - p10 - p7 - p6 - p2,$$

$$O_1 = p4 - \times - \times - \times - \times - \times - \times - \times - \times - \times.$$

Judging the penalty of punishment$C(ijk)$, if $C_{A_1}(12k) > C_{B_1}(12k)$, the series apart from the chosen position is rotated to right with the center of $B_1(2)$, and the second interim generation of A_2, B_2 can be obtained.

$$A_2 = \times - p9 - p2 - p6 - p3 - p8 - p1 - p5 - p10 - p7,$$

$$B_2 = \times - p9 - p3 - p8 - p5 - p1 - p10 - p7 - p6 - p2,$$

$$O_2 = p4 - p9 - \times - \times - \times - \times - \times - \times - \times - \times.$$

If $C_{A_2}(23k) > C_{B_2}(23k)$, the series of the second interim generation apart from the second chosen position B_2 (or A_2) is rotated to right with the center of $A_2(3) = p2$ (or $B_2(3) = p3$), and the third interim generation of A_3, B_3 can be obtained.

$$A_3 = \times - \times - p2 - p6 - p3 - p8 - p1 - p5 - p10 - p7,$$

$$B_3 = \times - \times - p2 - p3 - p8 - p5 - p1 - p10 - p7 - p6,$$

$$O_3 = p4 - p9 - p2 - \times - \times - \times - \times - \times - \times - \times.$$

Repeating the process, the generation of offspring can be achieved:

$$O = p4 - p9 - p2 - p3 - p8 - p1 - p10 - p7 - p6 - p5.$$

(8) Choosing the best optimal result: When the loop is ending, the result satisfying the objection function (54.5) in all generations considers as the final result.

54.4 Application of Hot Rolling Scheduling Method

The paper simulates the system of integration scheduling in the section of steel-making, continuous casting and hot rolling using the data from a domestic steel-making corporation. The simulation focuses on 2250 mm hot rolling mill and 1580 mm hot rolling mill, the former using two casters with both lines running and one caster with two strands used by the latter. Two slabs groups from many varieties and small batch production and few varieties and mass production as

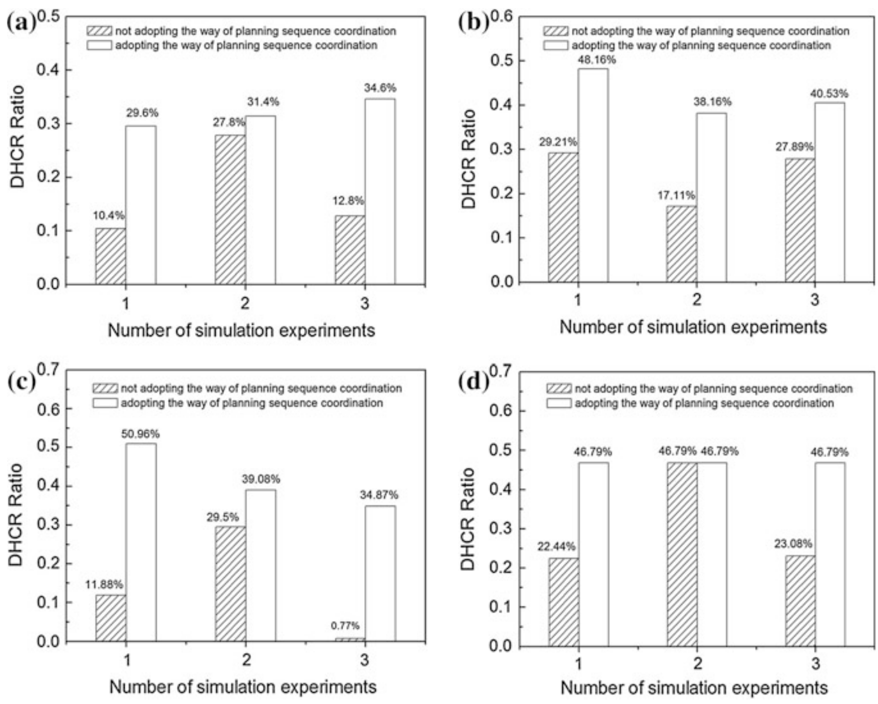

Fig. 54.1 Simulation results. **a** 2250 mm line for many varieties and small batch production, **b** 2250 mm line for few varieties and mass production, **c** 1580 mm line for many varieties and small batch production, **d** 1580 mm line for few varieties and mass production

research objects. There are 536 slabs classified under 9 varieties in the former and 761 slabs classified under 3 varieties for the latter. Assuming the two slab groups both are DHCR and HCR planning. Two groups of slabs are simulated three times, then compare the results of using the way of planning sequence coordination with the way of not. The simulation and the results follow as Fig. 54.1.

As shown in Fig. 54.1, the ratio of DHCR using the way of planning sequence coordination is better than the way not using both for rolling line 2250 and 1580 mm no matter many varieties and small batch production or few varieties and mass production are referred. The simulation results show that the model and its algorithm can coordinate the sequence of slabs getting out from continuous casting machine and the sequence of hot rolling, which is helpful to improve the ratio of DHCR.

54.5 Conclusion

(1) According to the analysis of the condition of DHCR and the main factors, it is available to improve the ratio of DHCR when the sequence of rolling batch planning keeps up with the sequence of slabs getting out from continuous casting machine under the rolling regulation, then the consistency factor of planning is proposed for showing the degree of planning sequence coordination.
(2) The optimal model of rolling batch planning for improving the ratio of DHCR is established on the basis of integrated production. It takes much more consideration for the coordination of hot rolling batch planning and the sequence of slabs getting out from continuous casting machine.
(3) The simulation of slabs from many varieties and small bath and few varieties and mass production using 2250 mm and 1580 mm rolling line has analyzed, and we can draw the comparison using the way of planning sequence with the way not adopted. The results show that the model and its algorithm can coordinate the sequence of slabs getting out from continuous casting machine and the sequence of hot rolling and can improve the ratio of DHCR. Our experiments have shown that such technology could get distinct results.

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Chapter 55
Research on the Location of Shenyang Guanghui Logistics Center of Agricultural Products

Shuang-wei Chen

Abstract The logistics center of agricultural products is a key link between the upstream production base and downstream vendors, and it plays a pivotal role in the whole logistics of agricultural products. Based on the case study of Shenyang Guanghui Logistics Center of Agricultural Products, this paper obtains the address coordinates of logistics center by the center-of-gravity method, and optimizes the results through several iterations. Finally, the best solution is selected from the alternatives by the elevation of analytic hierarchy process.

Keywords Agricultural products · Location · Logistics park · The centre-of-gravity method

55.1 Introduction

The market circulation of agricultural products is increasing in recent years. The agricultural products have the following characteristics: perishable, diverse kinds, high demand, numerous and scattered demand points. These characteristics require a high standard of transport and storage condition. According to the relative statistics, the loss percentage of fruits and vegetables can reach 20–30 % during the transport in China. Therefore, it is necessary to establish a logistics center of agricultural products to supply fresh agricultural products for the regional demand points in time. The logistics center of agricultural products, a transfer station of agricultural products, collects agricultural products from each production base, and then supplies products to each demand point. To improve the agricultural products logistics, location is the first problem to be solved. The scientific and rational

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location of logistics center not only can reduce the delivery time effectively in order to guarantee the freshness of agricultural products to the greatest extent and reduce the loss of agricultural products, but also can decide whether agricultural products are delivered to demand points safely, fast and timely. With reference to this, the location research becomes a focus for the logistics center of agricultural products.

Holmberg (1999) studied the optimal solution for location problems where the transportation costs were nonlinear and convex by a branch-and-bound method and Benders decomposition method. Verter and Dasci (2002) presented a mathematical model for the plant location, formulated a mixed integer nonlinear program and developed an exact algorithm and three heuristic algorithms to solve design problem. Gao and Zhang (2003) reviewed various determining factors about location of logistics center, and formulated a new location model by mathematics model, Delphi method, analytic hierarchy process, quantitative and qualitative analysis. Considering the perishable characteristics of agricultural products, Suo and Wang (2007) established a mixed integer linear programming model with the decayed rate, and illustrated the effectiveness of this method. Shi (2006) assumed that the decayed rate was proportional to the instant amount of goods, formulated the model which objective was to minimize transportation and distribution cost, and proposed the method of optimal solution by genetic algorithms. Based on the case study of Shenyang Guanghui Logistics Center of Agricultural Products, this paper makes the quantitative and qualitative analysis by the center-of-gravity method and analytic hierarchy process and obtains the best location solution.

55.2 Location Plan

55.2.1 Location Principle

The location of logistics center means to choose an address to set up the planning process of logistics center in an economic region with a number of supply points and demand points. Better location solution of logistics center is to achieve the best benefits of the whole process from the collection, transfer, distribution, until transportation to the demand point (Taniguchi et al. 1999). The scientific selection of agricultural logistics center should adhere to the following principles.

(1) *Adaptive principle*: The location of logistics center should be adapted for the guiding principles and policies of economic development of the country and province, for the resource and demand distribution of China's logistics, and for national economy and social development.
(2) *Coordinated principle*: The national logistics network should be considered as a large system in the location of logistics Center. The facilities and equipment of logistics center need mutual coordination in regional distribution, logistics productivity, technology level etc.

(3) *Economic principle*: In the process of logistics center's development, the cost on location mainly consists of construction expense and physical distribution expense. When the logistics center locates in urban, suburb or outer suburb, it is different for the construction scale and the logistics cost (construction cost, freight etc.) in the future auxiliary facilities. Therefore, the lowest total cost should be taken as the economy principle of location.
(4) *Strategic principle*: We should have strategic vision to determine the location. One is to consider the overall situation, and the other is to think about future profit (Chen 2001).

55.2.2 Influence Factors of Logistics Center Location

The influence factors can be divided into natural environment factor, social environment factor and infrastructure factor, including meteorological conditions, geological terrain, management factors, logistics costs, transportation, public facilities etc. Therefore, the following major points are considered in the location of agricultural logistics center.

(1) *Meteorology condition*: We should consider the regional indicators such as perennial rainfall, average humidity, wind strength, average temperature of each reason etc. If the logistics center supplies chiefly demand points in and around the city, we should consider the wind factor primarily. Because the windy region has strong wind, it can accelerate the water and freshness loss of vegetables.
(2) *Transportation cost*: Transportation cost is one of the important factors to select the location of agricultural logistics center. Because the price cardinal of agricultural product is low, the transportation cost will influence the additional price of agricultural products greatly. Thus, the logistics center should be close to demand area to ensure the lowest total cost of transportation.
(3) *Service level*: If perishable agricultural products cannot be carried to demand points timely, it will affect the price of agricultural products as a result of great losses. The service level is namely the extent to meet the demand. The satisfactory service should be guaranteed to the demanders whenever they issue the order to logistics center.
(4) *Traffic condition*: The major function of logistics center is the distribution. For this reason, the location should have convenient transportation conditions.
(5) *Land cost*: Logistics center covers a larger area. The land price must be considered. The additional conditions should be taken into account such as land value increment, land development costs and expanding space etc.

55.2.3 Common Location Method

As the previous domestic and foreign literatures shown, there are many location methods of logistics center, qualitative analysis and quantitative analysis. Qualitative analysis is to make decision based on individual or collective experience. The steps are firstly, to determine the evaluation indicators in terms of the experience, and then to test the superiority or inferiority of alternative centers by evaluation indicators, finally, to make a decision according to the test results. This method is simple and easy to operate, but it has empirical and subjective faults (Gao et al. 2005). Qualitative analysis includes mainly analytic hierarchy process and fuzzy evaluation method, etc. Quantitative analysis is to transform the location problem into a function on basis of all constraint conditions and the goal, then to use a suitable algorithm to find out the optimum solution. This method is relative accurate, but the data processing is usually quite complicated (Wei and Zhu 2000). Quantitative analysis includes mainly the centre-of-gravity method, mixed integer programming, CELP method etc.

The centre-of-gravity method is to choose a single logistics center. The transportation cost is the only decision factor and the goal is to minimize total transportation cost. The core of the algorithm is to determine the coordinates of supply and demand point and traffic volume among the dots. The model is: the total freight = (straight distance between facilities and customers) × demand. Geometrical experiment method is also effective. Demand point is regarded as the object system which distributes in a plane scope. The demand and resource of each point is regarded as the weight of the object respectively. The center-of-gravity point in object system is the best logistics dot (Gao and Zhang 2003).

55.3 Location Model

55.3.1 Calculation of the Initial Coordinates and Transportation Costs

Five major markets for agricultural products are located in Yuhong District, Dadong District, Dongling District, Sujiatun District and Shenbei New District as shown in Fig. 55.1.

For solving the model, assume that the freight rate of transport vehicle is R_i, the demand of various markets for agricultural products is Q_i. Transport cost has a linear relationship between transport volume and transport distance. The capacity of logistics center can meet the total demand of five markets. Table 55.1 shows the basic data.

To set up a logistics center which can cover five markets mentioned above, let the coordinates of the logistics center be (X, Y). According to the method of the center of plane object (Wei 2005), the following is obtained.

Fig. 55.1 Location map

Table 55.1 Basic data of the demand points

Distribution points	Demand Q_i (million tons)	Freight rate, R_i (yuan/ million tons km)	Coordinate, X_i	Coordinate, Y_i
Sujiatun market	13.55	110	574	0.12
Dongling market	20.84	110	8.17	2.84
Yuhong market	10.7	110	4.28	5.56
Dadong market	28.47	130	7.82	7.73
Shenbei market	30.1	130	8.26	11.08

$$X = \sum_{i=1}^{n} R_i Q_i X_i \Big/ \sum_{i=1}^{n} R_i Q_i$$

$$Y = \sum_{i=1}^{n} R_i Q_i Y_i \Big/ \sum_{i=1}^{n} R_i Q_i$$

The initial coordinates can be calculated according to the demand of each market (see Table 55.2).

The initial coordinates: $X = 93585.92/12574 = 7.443$; $Y = 85198.94 \ / \ 12574 = 6.776$

Calculating the distance between each distribution point and initial coordinates of logistics center $d_i = \sqrt{(X - X')^2 + (Y - Y')^2}$, and the initial total transport cost $C_i = Q_i R_i d_i$ (Han 2002) (see Table 55.3).

The coordinates of logistics center obtained at this time is not optimal, because it does not consider that existing resource points and demand points are not directly linked after setting up a logistics center. The products need transferring

Table 55.2 The calculation of the initial coordinates

Distribution points	X_i	Y_i	Q_i	Q_iR_i	$Q_iR_iX_i$	$Q_iR_iY_i$
Sujiatun market	5.74	0.12	13.55	1490.5	8555.47	178.86
Dongling market	8.17	2.84	20.84	2292.4	18728.91	6510.416
Yuhong market	4.28	5.56	10.7	1177	5037.56	6544.12
Dadong market	7.82	7.73	28.47	3701.1	28942.6	28609.5
Shenbei market	8.26	11.08	30.1	3913	32321.38	43356.04
Sum				12574	93585.92	85198.94

through the logistics center in order to change transport distance and transportation cost. Consequently, the above-mentioned method will be optimized.

55.3.2 Iterative Optimization of the Initial Program

From Table 55.3, we can obtain the point (X', Y'), the point of minimum total transport cost.

$$\frac{\partial d}{\partial X} = \sum_{i=1}^{n} R_i Q_i \frac{(X - x_i)}{d_i} = 0$$

$$\frac{\partial d}{\partial Y} = \sum_{i=1}^{n} R_i Q_i \frac{(Y - y_i)}{d_i} = 0$$

$$X' = \sum_{i=1}^{n} R_i Q_i x_i \Big/ d_i \Big/ \sum_{i=1}^{n} R_i Q_i \Big/ d_i$$

$$Y' = \sum_{i=1}^{n} R_i Q_i y_i \Big/ d_i \Big/ \sum_{i=1}^{n} R_i Q_i \Big/ d_i$$

Calculation process is shown in Table 55.4.

The new coordinates after the first iteration is:

$$X' = 43003.86/5638.26 = 7.627151$$

$$Y' = 41370.67/5638.26 = 7.337488$$

Table 55.3 The initial total transport cost

	Sujiatun market	Dongling market	Yuhong market	Dadong market	Shenbei market	Sum
d_i	6.870411	4.002577	3.388691	1.02579	4.380857	
C_i	10240.35	9175.508	3988.489	3796.551	17142.29	44343.19

Table 55.4 The first iteration

Distribution points	d_i	Q_iR_i	$Q_iR_iX_i$	$Q_iR_iY_i$
Sujiatun market	6.870411	1490.5	8555.47	178.86
Dongling market	4.002577	2292.4	18728.91	6510.416
Yuhong market	3.388691	1177	5037.56	6544.12
Dadong market	1.02579	3701.1	28942.6	28609.5
Shenbei market	4.380857	3913	32321.38	43356.04
Distribution points	Q_iR_i/d_i	$Q_iR_iX_i/d_i$	$Q_iR_iY_i/d_i$	
Sujiatun market	216.9448	1245.263	26.03338	
Dongling market	572.731	4679.213	1626.556	
Yuhong market	347.3318	1486.58	1931.165	
Dadong market	3608.048	28214.94	27890.21	
Shenbei market	893.2042	7377.867	9896.703	
Sum	5638.26	43003.86	41370.67	

Table 55.5 Transport cost after the first iteration

	Sujiatun market	Dongling market	Yuhong market	Dadong market	Shenbei market	Sum
d_i	7.460125	4.530131	3.789839	0.437329	3.795641	
C_i	11119.32	10384.87	4460.641	1618.598	14852.34	42435.77

Table 55.6 The results of iteration

The number of iterations	X	Y	The total cost
0	7.443	6.776	44343.19
1	7.627151	7.337488	42435.77
2	7.735866	7.61437	41228.35
3	7.791819	7.703724	41216.26
4	7.812483	7.724736	41131.66
5	7.818207	7.728836	41111.59
6	7.819582	7.729732	41106.92
7	7.819902	7.729937	41105.84

Table 55.5 shows the new distance of each distribution point and initial coordinates and the new transport cost.

From the calculation result in Table 55.5, the transportation costs decline clearly compared with the initial transportation costs, so the data is iterated continuously until the costs change a little or rebound. The results of iteration are shown in Table 55.6.

Fig. 55.2 The location map of two adjacent points

55.3.3 Analysis

After several iterations, the coordinate change of logistics center is almost negligible and the total transport cost changes a little, so the coordinates (7.82, 7.73) is regarded as the optimal location. As the existing building around this point, the two adjacent points are selected as alternative points, denoted as A and B. The location is shown in Fig. 55.2.

55.4 Analytic Hierarchy Process

The alternative locations A and B are obtained by the centre-of-gravity method. The following part will take qualitative and quantitative factors into account by AHP, and choose the best solution.

55.4.1 Establishing the Framework

The criteria hierarchy is the main factor that affects the location of agricultural logistics center (Li 2009). Alternative 1 and 2 are respectively corresponding to alternative points A and B. The framework is established (see Fig. 55.3).

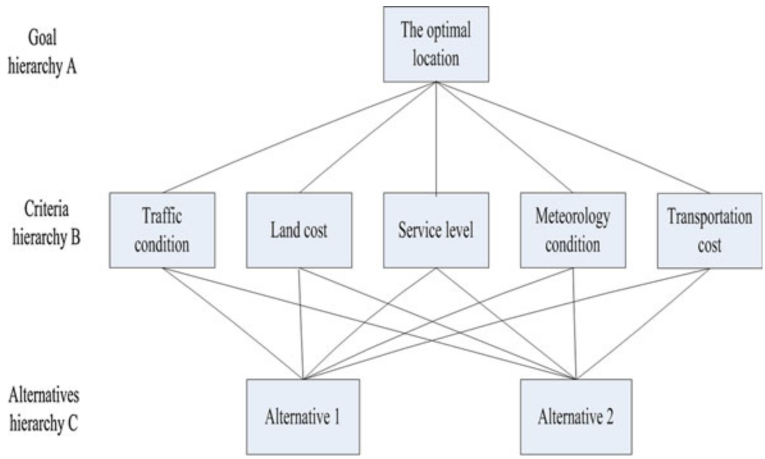

Fig. 55.3 Hierarchy framework of location

55.4.2 Constructing the Judgment Matrix of Hierarchy B and Consistency Test

Through the comparison of five factors of criteria hierarchy in pairs, we can determine the mutual important degree among the criteria for the best site, construct the judgment matrix B (Table 55.7), prioritize the influence degree of five factors and determine the main influence factors.

The calculation of matrix is shown in Table 55.8.

The eigenvector of judgment matrix is $W = [0.27, 0.42, 0.16, 0.05, 0.10]$, and the eigenvalue is $\lambda_{\max} = 2.449, C.I = \frac{\lambda_{\max} - n}{n-1} = -0.64$, when $n = 5, R.I = 1.12, C.R = \frac{C.I}{R.I} = -0.57 < 0.10$ the judgment matrix has satisfactory consistency.

55.4.3 The Sequence of Alternatives Hierarchy

Build judgment matrix from criteria hierarchy to alternatives hierarchy and make a consistency test. We can see the procedure from Table 55.9.

The hierarchical sequence is shown in Table 55.10.

55.4.4 Location Decision

Because the consistency indicator of five judgment matrixes is zero, the stochastic consistency ratio of alternatives sequence is $C.R = 0$. This indicates that

Table 55.7 The judgment matrix from hierarchy A to B

A_k	B_1	B_2	B_3	B_4	B_5
B_1	1	1/3	3	5	3
B_2	3	1	5	3	3
B_3	1/3	1/5	1	5	3
B_4	1/5	1/3	1/5	1	1/3
B_5	1/3	1/3	1/3	3	1

Table 55.8 Judgment matrix calculation

	B_1	B_2	B_3	B_4	B_5
B_1	1	0.3333	3	5	3
B_2	3	1	5	3	3
B_3	0.3333	0.2	1	5	3
B_4	0.2	0.3333	0.2	1	0.3333
B_5	0.3333	0.3333	0.3333	3	1

	Product of one row	$\sqrt[5]{}$	Sum	Normalization
B_1	15	1.7188		0.2698
B_2	135	2.6673		0.4187
B_3	1	1	6.3689	0.1570
B_4	0.004	0.3385		0.0531
B_5	0.1111	0.6444		0.1012

Table 55.9 Judgment matrix from hierarchy B to hierarchy C and consistency test

	B_1		B_2		B_3		B_4		B_5	
	C_1	C_2	C_1	C_2	C_1	C_2	C_1	C_2	C_1	C_2
C_1	1	3	1	1/5	1	3	1	3	1	1/3
C_2	1/3	1	5	1	1/3	1	1/3	1	3	1
W	$(0.75,0.25)^T$		$(0.16,0.83)^T$		$(0.75,0.25)^T$		$(0.75,0.25)^T$		$(0.25,0.75)^T$	
λ_{max}	2		2		2		2		2	
Consistency	C.I = C.R = 0		C.I = C.R = 0		C.I = C.R = 0		C.I = C.R = 0		C.I = C.R = 0	

Table 55.10 The hierarchical sequence

Hierarchy C	Hierarchy B					Hierarchy C sequence
	B_1 0.27	B_2 0.42	B_3 0.16	B_4 0.05	B_5 0.10	
C_1	0.75	0.167	0.75	0.75	0.25	0.455
C_2	0.25	0.833	0.25	0.25	0.75	0.545

hierarchical sequence has satisfactory consistency. Alternative B is the optimal location based on the results of Table 55.10.

55.5 Conclusion

This paper regards five markets of agricultural products as the object system, the market demand as the object weight, calculates the gravity center of object system as the initial coordinate of agricultural logistics center, does multiple iterative until achieving optimal results, applies AHP to the location of qualitative analysis, analyzes the influence of traffic condition, land cost, service level etc. on the location, finally obtains the optimal location.

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Chapter 56
Design and Implementation of a Real-Time Jobshop Scheduling System

Yi-hao Yu and Yan-hong Wang

Abstract In this paper, a data-based scheduling software system is presented for job-shops which operate in today's highly dynamic and uncertain competitive manufacturing environments. To incorporate the dynamic or uncertainty elements into the scheduling process, special emphasis is put on the real-time, dynamic behavior of the manufacturing system. The requirements of the scheduling system is analysis, subsequently, the details of the system model and the main function modules are described and implemented. One key feature of the proposed system is that the scheduling decision is making basing on the production data in manufacturing processes, not only those historical data but also these real-time data. Another feather is that it could make detailed, short-term production scheduler, which integrated the functions of real-time production monitoring and control, as well as coordination of component supply. Problem of various sizes are used to test the performance of the proposed system, and satisfactory results have achieved.

Keywords Job shop scheduling system · Real-time data based · System development and design

56.1 Introduction

Jobshop scheduling problem is always a hot topic in the theory and practice. Scheduling is a decision-making process that is concerned with the allocation of limited resources to competing tasks over a time period with the goal of optimizing one or more objectives (Huang et al. 2010). In theory, jobshop scheduling

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problems are NP-hard or mathematically intractable. For that reason, the research result shows that it is lack of effective scheduling problem modeling and optimization method which without the corresponding scheduling system to support (Liu 2009). Therefore, more efforts should be made not only in the research of scheduling algorithm in theory, but also need to explore effective way to designing and developing scheduling system.

In the area of design and develop scheduling system, Murata et al. (2006), Book and Bhatnagar (2008), Shobrys and White (2005) provide a method to realize the multilayer distributed system, Deng et al. (2011) put forward the method to realize the jobshop production schedule system which is based on information integration, Wang and Liu (2011) put forward the research based on multilayer integrated dynamic production scheduling system, Shao et al. (2010) put forward the research method of the design and optimization of database management system of finishing jobshop, Wang et al. (2010) design the method to use machine learning algorithm to realize complex problems in scheduling system, Sun (2002) research the scheduling optimization of job-shop in intelligent manufacturing system. And the existing literature also exist some shortage to overcome, for example, most systems rarely consider the large amounts of data that accumulated in the production process of the manufacturing process. In fact, the researcher can get more effective information through this data, and this data can provide more effective evidence for dynamic scheduling method and make scheduling results more adapt to dynamic scheduling environment. Koonce and Tsai (2000) provide a method which combined by genetic algorithm and data mining knowledge to solve the jobshop scheduling problem. Many systems consider more in the system function and consider less in the influence and guidance of the actual manufacturing process in the aspect of design and implementation system, they often only show the scheduling list on the interface. For these requirements, there is a mount of historical and real-time data in the job shop manufacturing process management, this paper designs and develops a jobshop scheduling system based on this data.

Since the accurate real time data is the most valuable information for manufacturing enterprises, this paper combines the scheduling method based on the rules, the method of forecast (Liu et al. 2008a; Zhou et al. 2008) with the method of rolling rescheduling (Liu et al. 2008b, 2009) to realize the workshop manufacturing management information system, and in this paper a data-based scheduling software system is also elaborately designed for job-shops operating in today's competitive environments full of uncertainty and the dynamic elements.

56.2 Modeling

At present, as the complex processing environment in the mechanical processing enterprise, and most processes of production scheduling still stay in the manual way, for the situation of which has complex basic data still cannot reach the goal to use human, material, equipment resources reasonably to get the optimal production results.

In this paper, the function of jobshop scheduling system is integrated with some functions of general real-time production monitoring, control, and component supply coordination. Firstly, the system needs to deal with the complex basis data, and uses the data mining knowledge to get the training data that used. Secondly, using large amounts of data as the foundation, the system realize basis data management, production scheduling, inventory management, and information query and statistics functional module to implement the visualization of processing jobshop operation. Therefore, an ideal jobshop scheduling system should include the following modular, including user management, basic data management, production scheduling, inventory management and information query and statistics, and so forth.

In this paper, the system shows the processing machine of each machining process, processing conditions, start time of machining, end time of machining, and the number of last processing operations through the form. The system could also display status of the machines and operators in the job shop through the form of chart, and inquiries processing status according to different constraint conditions. For these purpose, the use case diagram of system has been designed (see Fig. 56.1).

56.3 System Design

The more important capability of the scheduling system is that it could utilizing more dynamic information in the shop floor and make full scheduling, with global perspective and avoidance of myopic decision-making, so as to reduce the uncertainly feature in actual production process. Using the database as the software backstage, here the scheduling system is designed under the VC++ 6.0 environment.

According to the results of system requirement analysis, the scheduling system should contain three parts. The first part is Data Analysis, which gets effective data through the data mining knowledge. The second part is Database Designing, which can storage history data and real-time data. The third part is Software Designing, which programming a jobshop scheduling system to realize the visualization of machining or other operations in manufacturing processes. The flow chart of the system was shown as Fig. 56.2.

Jobshop scheduling system involves large amounts of data; the data not only can make the operator inquiry the jobshop working condition more directly, but also provide raw data for the data analysis further. The system gets the historical data and real-time data of jobshop production through the data acquisition system firstly, and uses data mining method to analyse data, and then judges the historical data and the real data to generate the scheduling algorithm. That is to say, the

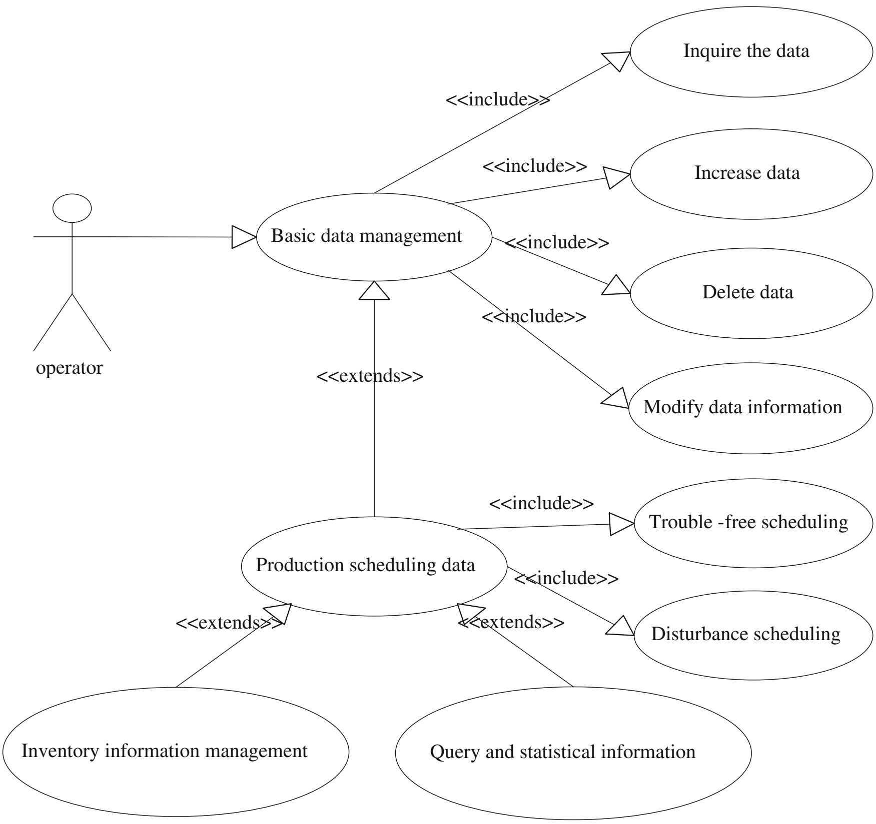

Fig. 56.1 The system use case diagram

jobshop production scheduling system runs algorithms basing on a lot of manufacturing data. According to the requirement analysis of system, the form in the database can be divided into several forms, such as, the job information table, order information table, historical data table, scheduling results table, machine information table, operation information form. The function of database can be described as Table 56.1. The core data flow chat of scheduling module was shown in Fig. 56.3.

56.4 System Implementation

According to the results of the system requirement analysis, the main components of system include basic data management module, production scheduling module, information query and statistical module. The block diagram of the system was shown as Fig. 56.4. Some modules are discussed now in detail.

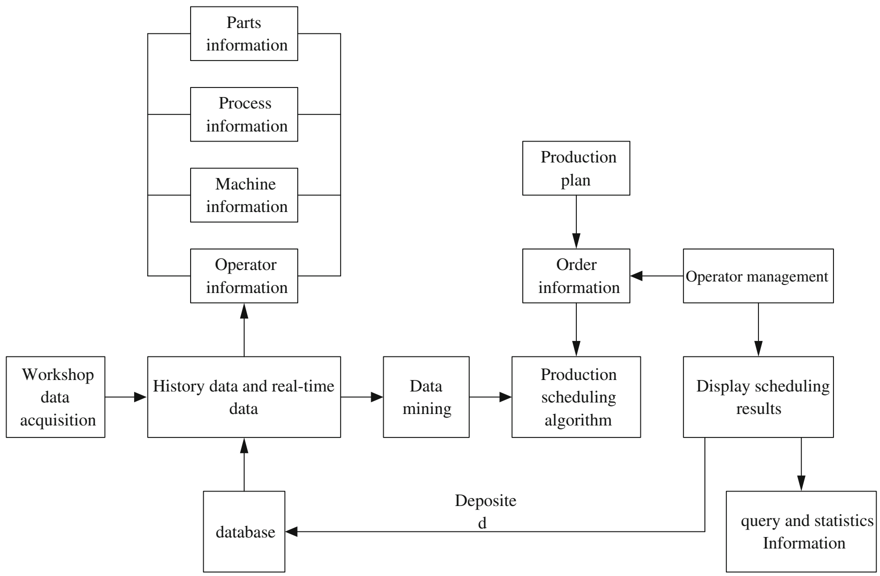

Fig. 56.2 The system flow chart

Table 56.1 System function table

Module function division		Data table	Functional description
	Parts kinds	Job	Record the information of different kinds of parts
Comprehensive information	Machine types	Machine	Record numbers and types of machine
	Process information	Indexwork	Record numbers and types of process
The process information of parts		Index_itme	Record all process information of each part
Machine information		Machine_itme	Record the process which can process on each machine
Scheduling results		Result	Record the scheduling results of all order information
Order management		Order	Record information of each order
Operator permissions		Admin	Record information of different permissions of operator

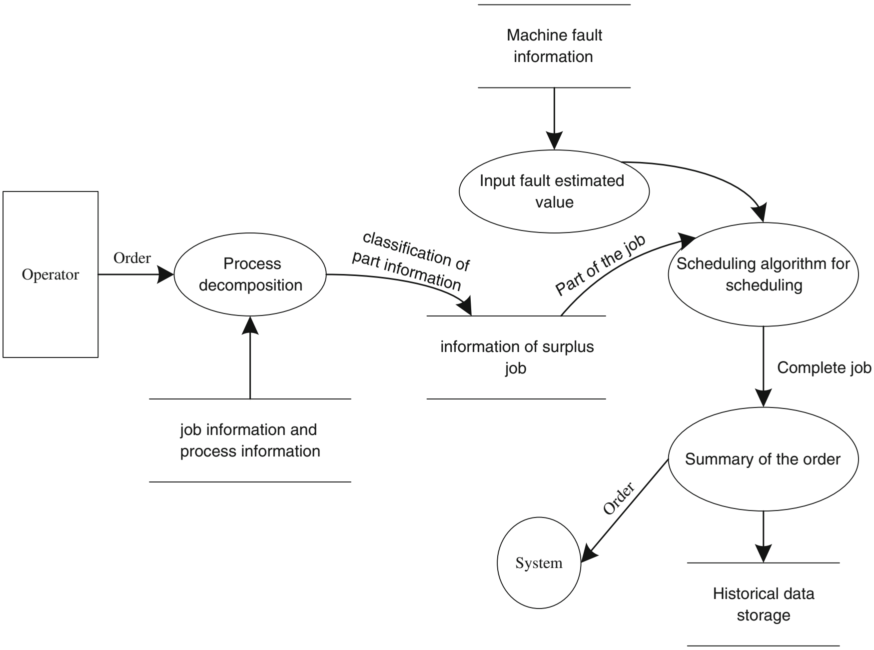

Fig. 56.3 Data flow chart of scheduling of module

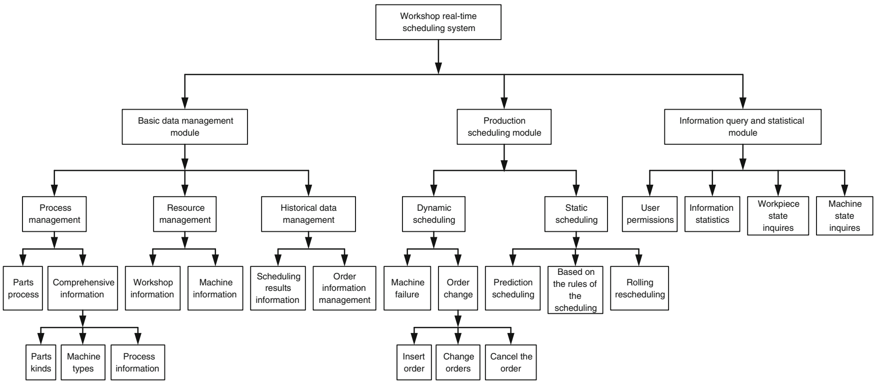

Fig. 56.4 Block diagram of the system

(1) Basic data module. The system stores the historical data as source data in databases. Those data were obtained through data analysis, and the system regards this data as the foundation of production scheduling. The data processing interface shown as Fig. 56.5.

Fig. 56.5 The data processing interface

(2) Production scheduling module. Production scheduling module is a central part of the whole system. Scheduling algorithms in the background are on rule-based scheduling (Zhou et al. 2008). The scheduling interface was shown as Fig. 56.6.
    This paper uses the method combined by forecast scheduling method and rescheduling method to dispatch the parts (Liu et al. 2008b, 2009). The operator may give a estimated value of breakdown based on the historical data information, if the breakdown is eliminated in estimated time range, the operator uses the method based on rules to rescheduling the parts, otherwise, the operator should give another estimated value until the breakdown is eliminated. The scheduling interface with disturbance was shown as Fig. 56.7.
(3) Information query and statistical module. This part contains the inventory information management and information inquiry and statistics. This module records the information of parts which are already finished and storages this information as the form of historical data tables in the database. The data could be operated through the query and statistics module (see Figs. 56.8 and 56.9).

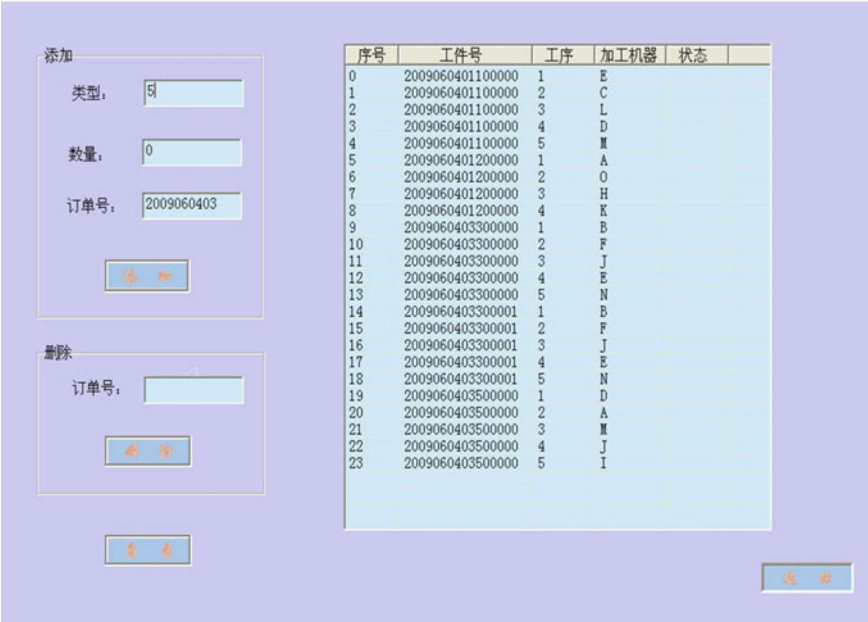

Fig. 56.6 The scheduling interface

Fig. 56.7 The scheduling interface with disturbance

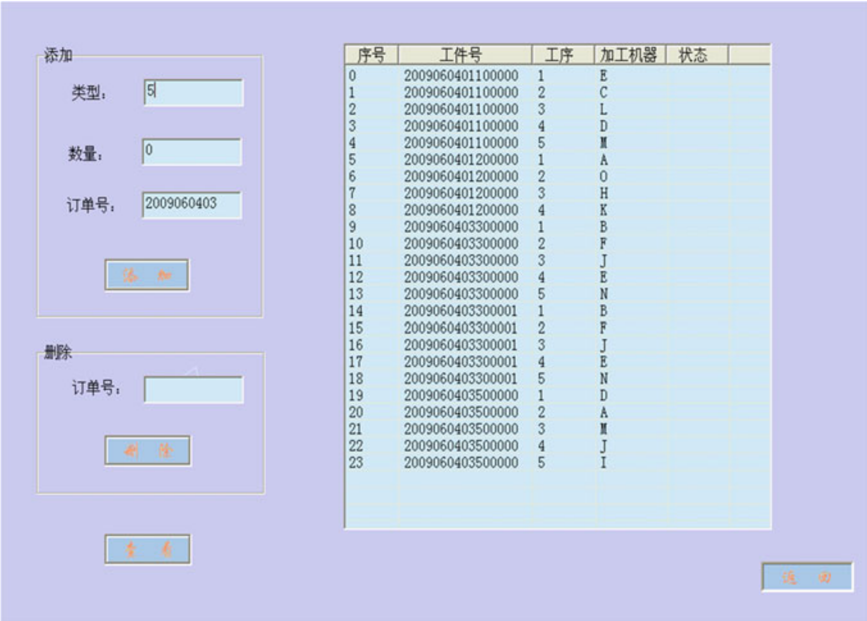

Fig. 56.8 The query and statistics interface (a)

Fig. 56.9 The query and statistics interface (b)

56.5 Conclusion

According to the practical problems of jobshop production scheduling, this paper design investigate a scheduling system to deal the complex requirements in manufacturing scheduling under the environment of dynamic challenge. For data in the complicated production process, data mining is used to get some useful rules and knowledge to make production scheduler. Basing on the processing data and information in manufacturing system, including the real-time data as well as the historical data, the rolling rescheduling method was used to deal with several interruptions which exist in production process. Besides, the processing status of each process could be displayed conveniently, and Gantt charts were used to show the using condition of machine equipment, making the operation more simple and intuitive. Future work should to further optimal the scheduling algorithm and do some detail work to make the system more perfect. Some efforts also include making the scheduling module and jobshop management module integrated more closely, so that the system is more adaptable to the actual production environment.

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Chapter 57
The Lean Optimization Design of the Performance Evaluation Index System of Small and Medium Manufacturing in Lean Revolution

Jun Li, Fu-xing Zhang and Ya-juan Qu

Abstract At the base of enhanced Balanced Scorecard (BSC) method, this paper determined the performance evaluation index set of small and medium manufacturing lean revolution from a strategic point of view. According to the causality chain of evaluation index, it established evaluation model with ANP method and determined the weights of evaluation indexes with Super Decision software. Finally, it took the performance evaluation of lean revolution in production department "A" factory as an example, and the calculation results showed that this evaluation model is specified the direction of the efforts of promoting lean revolution continuously for a small and medium manufacturing in China.

Keywords ANP · BSC · Index system · Lean revolution · Performance evaluation Small and medium manufacturing

57.1 Put Forward Questions

At present, under the intense pressure of market competition, many of our small and medium manufacturing are attempted to implement the lean production mode. But unfortunately, many companies are died in a natural. This paper argued that most of companies have not put the lean revolution into a strategic position, only taking it as sporadic implementation tools. Although the application of some tools

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in the short term can achieve some effect that enhance the profitability of the enterprise or reduce production cost, but difficult to maintain long-term (Zhang 2010). Therefore, this paper built a lean revolution performance evaluation index system form the point of strategic through enhanced Balanced Scorecard(BSC), and then according to the dependence among evaluation index, used the method of Analytic Network Process(ANP) to establish evaluation model and determine the weights of evaluation indexes. The purpose is to specify the effort direction of some small and medium manufacturing promoting lean revolution continuously, which is designed from the view of strategic.

57.2 Analyze the Evaluation Index

BSC can implement the strategic performance powerfully, and enhanced BSC considers the establishment of small and medium manufacturing lean revolution performance evolution index from six main aspects. Specification as follows: ① financial aspects: BSC can take the financial index as the focus of objective, because of all the improvements should ultimately attributable to the achievement of financial goals. The measure of financial index mainly included four aspects: profitability, operational capacity, solvency and development ability. ② internal processes: Enterprises must develop new products or services which can meet customer requirement in the process in order to meet customer changing needs, including planning and control, inventory control, after-sales service, internal management and other aspects. ③ customer aspects: customer level of BSC can transform the enterprise's mission and strategic into the specific target of the target customers and market segments, and then communicate to the entire enterprise (Xu 2009). ④ learning and growth: leaning and growth is the basis of enterprise long-term continuous development and progress, including employee skill levels, employee career development, employee motivation, organization information systems. ⑤ other stakeholders: including operator, competitors, suppliers, government, society public, and suppliers given priority to affect the key link of implement lean production. The related index of measure supplier included effective information mutually feedback, JIT supply rate, long-term cooperation and persistence of main supplier. ⑥ strategic planning and development: The indexes of strategic planning and development require the enterprises must have a long-term perspective, in order to create value for a long period of time (Zhong and Zhao 2006; Wang et al. 2006). Mainly refers to the senior leadership can make a reasonable, challenging long-term, medium, short-term objectives and annual plans.

Therefore, according to the analysis of the Enhanced Balanced Scorecard and the impact factors of lean production implementation process, this paper takes the most typical department-level assessment index as example, and then analyzes lean production performance evaluation indexes which based on enhanced BSC, those index set are showed in Table 57.1.

Table 57.1 Lean production performance evaluation index collection

Index type	Strategic goals	Key indexes
Financial A	Increase profitability	Net assets yield A_1 = net profit/net assets
	Improve operational ability	Total capital turnover A_2 = sales revenue/total assets
	Improve debt paying ability	The asset-liability ratio A_3 = total liabilities/total assets
	Improve development ability	Sales growth ratio A_4 = this year's sales/the last year's sales
Internal processes B	Improve operational efficiency	Business process improvement B_1 (strengthen internal management)
	Strengthen innovation ability	New product launch ability B_2 (new product launch speed, new products to total sales ratio)
	Pursuing the zero inventory for the target	Inventory turns B_3 = operating income/(initial inventory amount + final inventory amount)/2
	Meet customer demand continuously	Product improvement and development B_4 (creating values as the first task)
	Improving manufacturing efficiency	Product quality B_5 (qualified product ratio = qualified products/total product)
Customer C	Customer oriented, increase the number of profit customers and proportion	The rate of obtained new customer C_1 = profit of new customers gained/total sales profit
		The rate of lost customers C_2 = lost customers/total customers
		The rate of customer complained C_3 = complained customer/total customer
	Improve customer repeat purchase rate	Customer satisfaction C_4 (through the questionnaire and result analysis)
Learning and growth D	Enhance enterprise learning ability	Employee satisfaction D_1 (through the questionnaire and result analysis)
	Improve staff skill level	Rate of staff training D_2 = the numbers of participate in training/the total department number
	Planning staff career development	Promotion and incentive D_3 (develop staff potential)
		Employee turnover D_4 = numbers of mobile staff/total employees
	Improve the ability of information system	Information feedback and processing speed D_5 (sensitivity of information system, utilization of information equipment)

(continued)

Table 57.1 (continued)

Index type	Strategic goals	Key indexes
Other stakeholders E	Improve the long-term cooperation with the supplier	Qualified rate of Raw material product E_1 = numbers of qualified products material/total of material product
	Demand-pull production	The supply rate of JIT E_2
	Timely and effective communication with supplier	Mutually effective information feedback E_3
Strategic planning and development F	Make the reasonable and challenging development goals for enterprise	Industrial environment and policy research and analysis F_1
		Make the strategy development plan for the whole company and some departments F_2

57.3 Establish Evaluation Model

From the leadership point of view, in the fierce competition market environment, enterprises want to develop for long, and need to continuously bring profits and create value for customers, shareholders, employees and stakeholders. This paper takes the enterprise profits maximizing as the overall goals, for six dimensions: financial, internal processes, customers, leaning and growth, other stakeholders, strategic planning and development, and multiple lower-level indicators was decomposed by layer in their respective dimension. There is a correlation between the indicators (Song and Wang 2010; Bhasin 2008), and the chain of causation between them is showed in Fig. 57.1.

According to the chain of causation among the evaluation index showed in Fig. 57.2, in order to reflect the correlation among the indexes scientifically, this paper uses ANP method of the feedback characteristic to evaluation the indexes, and then adopts Super Decision (SD) software to establish ANP model of a performance evaluation index system. The relational degree of indexes is showed in Fig. 57.2.

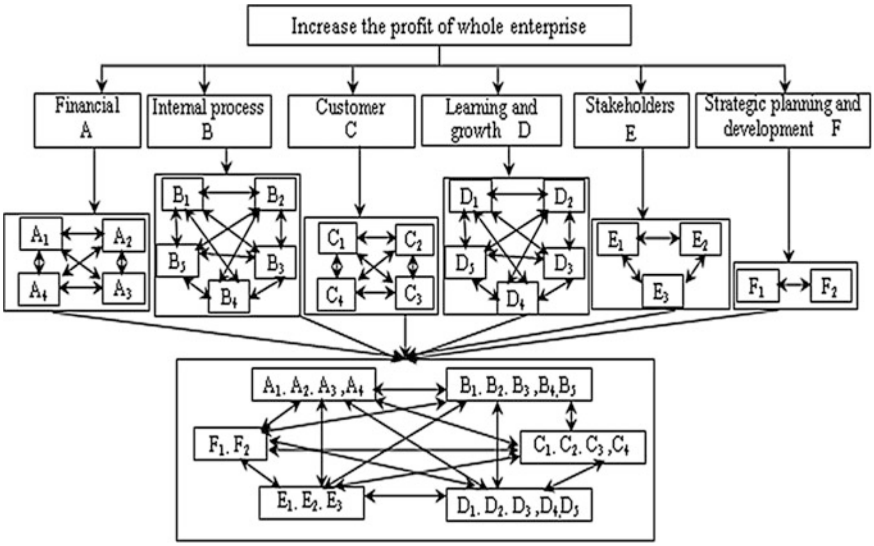


Fig. 57.1 The chain of causation between the evaluation indicators

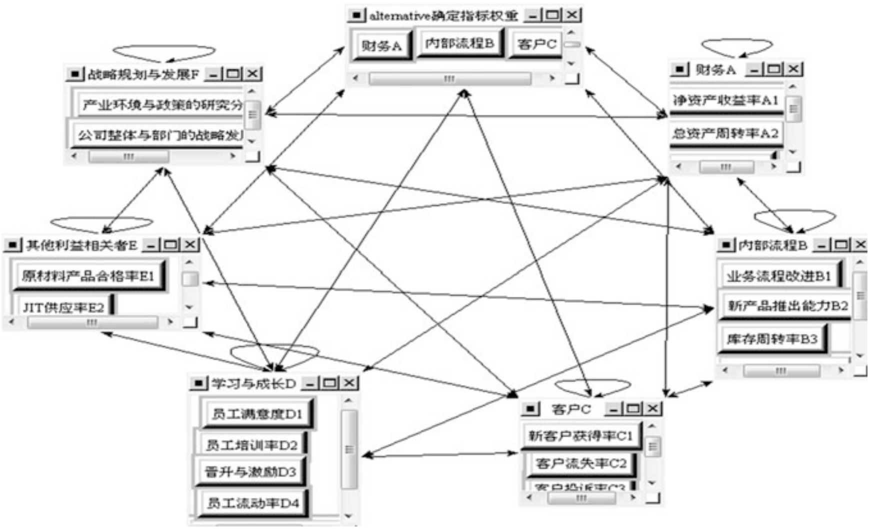


Fig. 57.2 Enterprise lean revolution performance evaluation model based on the ANP

57.4 Determine Weights of Evaluation Indexes

57.4.1 Calculation Steps

Using the SD decision software determined the steps of index weight are as follows:

(1) Construct judgment matrix. When establishes the judgment matrix, this paper adopts expert scoring method combines with data collection method to compare and evaluates the importance degree, and takes the weighted average as final value, and through the ANP application software SD to compare the index importance degree and make consistency check. The scoring interface of SD software is showed in Fig. 57.3.

(2) Calculate weighted super matrix. Calculate the weighted super matrix W and list the normalized. Weighted super matrix reflects the main factor control of the sub-factor and the feedback of sub-factor to main factor (Huson and Nanda 1995; Matsui 2007; Kojima and Kaplinsky 2004). In order to calculate conveniently, it needs to list each column normalized of exceed matrix and need realize with a weighted matrix, namely weighted matrix $a_{ij} \times$ super matrix w_{ij}.

(3) Calculate limit super matrix. Calculate limit Super matrix $\lim_{k \to \infty} w^k$. Set w_{ij} is the element of weighted super-matrix W. The size of w_{ij} reflects the step dominance of element i to element j. Through the SD software, the paper obtains index weight of the six elements which include finance, internal process, customer, leaning and growth, other stakeholders, strategic planning

Fig. 57.3 SD software scoring interface

and development, and the lower-level indexes of these elements. Its limit super matrix is showed in Fig. 57.4.

(4) Calculate the index weight. Calculate the weight of lean production evaluation index and other related factors influenced each index through SD software. We can grasp different factors the important degree more comprehensive by analyzing the sorting result which impact lean revolution

This paper takes production department of "A" factory for example, combines with the evaluation index system, and then makes empirical analysis using ANP method and SD software. Through SD software, the specific weight of every index can be obtained, and the index weight size of ultimate limit matrix was showed in Table 57.2.

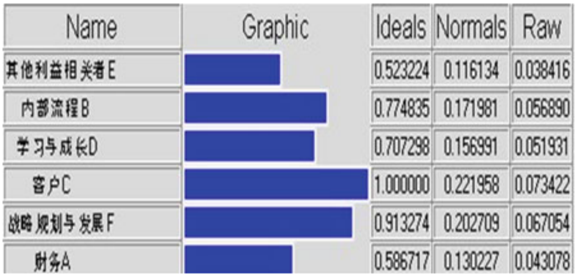
Cluster	Node Labels	alternative确定指标权重						其他利益相关者 E	
		其他利益相关者 E	内部流程 B	学习与成长 D	客户C	战略规划与发展 F	财务A	JIT供应率 E2	原材料产品合格率 E1
alternative确定指标权重	其他利益相关者 E	0.038416	0.038416	0.038416	0.038416	0.038416	0.038416	0.038416	0.038416
	内部流程 B	0.056890	0.056890	0.056890	0.056890	0.056890	0.056890	0.056890	0.056890
	学习与成长 D	0.051931	0.051931	0.051931	0.051931	0.051931	0.051931	0.051931	0.051931
	客户C	0.073422	0.073422	0.073422	0.073422	0.073422	0.073422	0.073422	0.073422
	战略规划与发展 F	0.067054	0.067054	0.067054	0.067054	0.067054	0.067054	0.067054	0.067054
	财务A	0.043078	0.043078	0.043078	0.043078	0.043078	0.043078	0.043078	0.043078
其他利益相关者 E	JIT供应率 E2	0.018394	0.018394	0.018394	0.018394	0.018394	0.018394	0.018394	0.018394
	原材料产品合格率 E1	0.020182	0.020182	0.020182	0.020182	0.020182	0.020182	0.020182	0.020182

Fig. 57.4 Index limit super matrix

Table 57.2 The weight size of limit matrix

Name	Limiting	Normalized by cluster
Other stakeholders E	0.011204	0.11613
Internal process B	0.05689	0.17198
Learning and growing D	0.051931	0.15699
Customers C	0.073422	0.22196
Strategic planning and development F	0.067054	0.20271
Financial A	0.043078	0.13023
E_1	0.020182	0.36957
E_2	0.018394	0.33683
E_3	0.016033	0.2936
B_1	0.032513	0.24803
B_2	0.019963	0.15229
B_3	0.02145	0.16363
B_4	0.027206	0.20754
B_5	0.029955	0.22851
D_1	0.027967	0.34084
D_2	0.011075	0.13497
D_3	0.009251	0.11274
D_4	0.018541	0.22596
D_5	0.01522	0.18549
C_1	0.02081	0.12821
C_2	0.041911	0.25821
C_3	0.027148	0.16726
C_4	0.072443	0.44632
S_3	0.038833	0.41019
F_1	0.068848	0.46269
F_2	0.07995	0.53731
A_1	0.021998	0.24348
A_2	0.016872	0.18674
A_3	0.01105	0.1223
$\mathbf{A_4}$	0.04043	0.44748

Seen from Table 57.2: ① the order importance of indexes on other stakeholders is: $E_1 > E_2 > E_3$; ② the order importance of indexes on internal process of: $B_1 > B_5 > B_4 > B_3 > B_2$; ③ the order importance of indexes on leaning and growth is: $D_1 > D_2 > D_5 > D_4 > D_3$; ④ the order importance of indexes on customers: $C_4 > C_2 > C_3 > C_1$; ⑤ the order importance of indexes on strategic planning and development is: $F_2 > F_1$; ⑥ the order importance of indexes on financial is: $A_4 > A_1 > A_2 > A_3$. Therefor, the specific index order importance comparison results of every factor, which contained in the six factors of the control layer, indicated the effort direction for improving various abilities in the process that enterprise can advance lean revolution continuously.



Name	Graphic	Ideals	Normals	Raw
其他利益相关者E		0.523224	0.116134	0.038416
内部流程B		0.774835	0.171981	0.056890
学习与成长D		0.707298	0.156991	0.051931
客户C		1.000000	0.221958	0.073422
战略规划与发展F		0.913274	0.202709	0.067054
财务A		0.586717	0.130227	0.043078

Fig. 57.5 The synthesis order results

57.4.2 The Synthesis Order Results

The synthesis order results showed in Fig. 57.5. The data of "Raw" column can directly from the limit matrix of. And "Normals" column shows the evaluation results in the form of priority, and the data from the figure shows that the order importance of each index is: C > F > B > D > A > E. "Ideals" column is obtained from each entity divided by maximum through the maximum the "Normals" column.

57.5 Conclusion

Analysis evaluation elements from the perspective of enhanced BSC, using ANP method to evaluate, and then founds that the importance degree of six factors is C > F > B > D > A > F, which had the implementation effect of small and medium manufacturing lean revolution. Therefore, in the process of planning enterprise strategy and development, senior managers should investigate the different markets and customer groups, as well as the preferences of price, quality, function, image, goodwill, relationship, response and service, and then enterprise can choose customers and market segments targeted (Bayou and de Korin 2008; Kasul and Motwani 1997; Saaty 2001; Saaty 1991; Wu and Lee 2007). Saw from the evaluation result, strategic planning and development plays an important role in the effect of enterprise implement lean revolution, and this factors' reflects the promotive effect which enterprise senior leaders implement the lean revolution, senior leadership should decompose the long-term goal, medium-term target, short-term goals to the middle, grassroots, frontline employees scientifically and reasonably, and make their effort to achieve their objectives required effect, finally contributed to realize the enterprise overall goals inevitably.

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Chapter 58
The overall Merit of Master Production Schedule Based on Rolling Planning Cycles and Freezing Parameters

Xiao-feng Ning, Ni Du and Kuan Yu

Abstract Nowadays, customer demand in manufacturing industry changes more frequent, moreover, the requirement of lead-time should be minimized. Therefore, manufacturing enterprises should make the MPS rapidly according to the limits of the existing resources. The uncertainty of demand and supply makes the production enterprises frequently change MPS to adapt to changes. However, excessive modify MPS will cause the instability of the production plan or Nervousness. Instability will lead to capacity reduced, the service level decreased, and the total cost increased. The paper provides an advanced merit which contains all aspects of MPS performance: instability, costs and service level and evaluates in one model. This paper studies on the influence from freezing MPS to the overall performance in the assumptions which demand is uncertain; the production is in the same level, the production capacity is existed. The result demonstrates that planning horizon, freezing proportion and re-planning periodicity dramatically influence the performance of instability, costs and service level.

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Keywords MPS · Instability · Service level · Total cost

58.1 Introduction

Along with the market economy's rapid development, customer demand changes more frequent, the requirement of lead-time should be minimized. The manufacturing enterprises should make the MPS rapidly according to the limits of the existing resources. The uncertainty of demand and supply makes the production enterprises frequently change MPS to adapt to changes. However, excessive modify MPS will cause the instability of the production plan or Nervousness (Sridharan and LaForge 1990). Instability will lead to capacity reduced, the service level decreased, and the total cost increased (Ho and Carter 1996). One of the effective methods to reduce the instability is freezing the MPS, which plan to part of the cycle time is set be unchangeable unless the special circumstances; the rest of the time, according to the change of the supply and demand can be modified.

Schedule instability problem was first introduced by Steele in 1975. He suggested using a fixed EOQ or a Lot-for Lot scheduling rule in order to alleviate the effects of nervousness. Sridharan et al. (1988) examined the effect of freezing methods on master production schedule (MPS) stability by comparing production and inventory costs. They further used a new measuring method for single-level schedule instability and analyzed the effect of costs. Zhao and Lee (1993) developed the research by Sridharan from single-level systems to multi-level planning systems. They also investigated the impact of parameters for freezing the MPS on total cost, schedule instability and service level of multi-item single-level systems with a single level resource constraint under deterministic demand and stochastic demand.

However, only little research has been carried out on theoretical analysis of instability and in the supply chain environment. The effect of inventory control rules (s, nQ), and (s, S) on planning stability in a single stage inventory system with stochastic demand was investigated in the studies by Jensen (1993), Kok and Inderfurth (1997). Papachristos and Ganas (1998) presented rules concerning the optimal policy and stability regions for the single product periodic review inventory problem with stationary demands.

Buffer stock is generally believed to have a dampening effect on schedule instability (Mather 1977), End-item safety stock absorbs changes at the top level, thus reducing the amount of nervousness transmitted to lower levels. Sridharan and LaForge (1994) showed that, under uncertain demand conditions, introducing a small amount of safety stock helps to reduce both instability and cost. Increasing the amount of safety stock, however, increases both cost and schedule instability, without an appreciable increase in service level. Comparing three methods for determining safety stock levels, Cambell (1992) found that as the number of frozen order intervals increases, so may the need for safety stock.

An examination of the instability measures in MRP systems indicates that none of the measurement methods capture all aspects of the instability, and all of them have some shortcomings (Heisig 2002). For instance, BKM metric depends on enumeration and fails to assess changes in open orders within the cumulative lead-time. Further, SBU metric takes into account single-item, single-level situations, and it is biased due to the fact that total number of orders depends on the item cost structure. Although, KS metric gets rid of the bias by not dividing the total instability to the total number of orders, there is no distinction between setup and quantity changes.

Existing production plan for quantitative research of the stability is not much, and not combined with the total costs and the service level in calculation. However, fully meet customer requirements and try to reduce the cost of product is the enterprise in the fierce competition in the market gain the key to success. The article established the overall merit of master production schedule based on instability, costs and service level, which consider the performance in freezing mps circumstance.

58.2 The Overall Merit of Master Production Schedule Based on Instability, Costs and Service Level

58.2.1 Assumptions

(1) Enterprise adapts make-to-stock production, which consider safety stock and it remains the same.
(2) The MPS based on demand forecast, which is uncertain but has the fixed mean and standard deviation.
(3) Using Lot for Lot production technique, which generated planned orders in the number of demand for each time period, is equal to the net.
(4) The MPS is in the rolling production schedule circumstance, and could be set some freezing proportion.
(5) When the orders are expedited or postponed, the quantities cannot be changed.
(6) Considering delay in delivery, and that, along with the increasing of delay time, the delay cost will be increased and the customer service level will be decrease rapidly.

58.2.2 The MPS Instability Model

The most commonly used production plan not only consider the stability model plan production quantity of the change, the considered factors are inadequate; Moreover, it is not percentage form, not easy to analysis. In this paper, we established the instability model based on the work done by kabak (Kabak and Ornek 2009).

The instability in period k contains two sub-models, and considers their Weight Coefficients.

$$I(k) = w_1 I_Q(k) + w_2 I_O(k) \tag{58.1}$$

The notation is defined as follows:

$I(k)$: schedule instability in period k

w_1, w_2: the Weight Coefficients, and $w_1 + w_2 = 1$

$I_P(k)$: quantity-oriented POR instability for planning cycle k

$I_S(k)$: quantity-oriented SR instability for planning cycle k

The first sub-model is the quantity-oriented POR instability. It looks like the common schedule instability model, which takes absolute differences of planned order quantities between two successive cycles, and multiplies by the weight function $(W(t))$ for planned orders. Then, the result divides the total maximum weighted POR quantity deviations between planning cycle k and k − 1(ΔQ).

$$I_P(k) = \frac{\sum_{t=M_k}^{M_{k-1}+N-1} \left|Q_t^k - Q_t^{k-1}\right| W(t)}{\Delta Q} \tag{58.2}$$

W(t) is the weight function for planned orders, $W_P^Q(t) = A(t - M_k)^{-B}$, where A and B are constants and A = 1.8 and B = 1.4.

Along with the increase of freezing proportion, the changes of the POR quantity in same t in contiguous planning horizons decrease rapidly. Therefore, the quantity-oriented POR instability also decreases. According to our previous research data, the downtrend is very obvious.

The second sub-model is quantity-oriented SR instability, which indicates the absolute differences of open order changes for a given planning cycle k. In other words, this measure considers the effect of shift in quantity when a setup is expedited or postponed to another period (Xie et al. 2003). The open order is the order which have not been finished, and is more important than the POR order. Therefore, this sub-model can be interpreted as the quantity of SR order (${}^{O}Q_t^k$) multiplied by the weight function ((W(NDD$_i$) + W(ODD$_i$)), then divide the total maximum weighted SR quantity deviations between planning cycle k and k − 1(Δq). Because the SR orders are more important than the POR ones, the weight function of SR is higher than POR ones.

$$I_S(k) = \frac{\sum_{t=M_k}^{M_{k-1}+N-1} |\delta|^{O} Q_t^k [W(NDD_i) + W(ODD_i)]}{\Delta q} \tag{58.3}$$

$W(NDD_i) + W(ODD_i)$ is the weight function of open orders, and $(W(NDD_i) + W(ODD_i) = (A')(t - MK)^{-B}$, $A' = c_t^P c_T^S$. c_t^P is the coefficients of planned orders for tth period, for t = 1,…, P. c_T^S is the minimum coefficient of open orders for Tth period.

Along with the increase of freezing proportion, the quantity changes of the SR quantity decrease. Moreover, the frequency of expedited or postponed orders is decreased. Therefore, the quantity-oriented SR instability is also reduced.

58.2.3 The Cost Model

The cost which influences the MPS contains three parts: the setup cost, the holding cost and the backlogging cost. For convenience, the introducing the indicative function $\delta(x)$ for describing setup cost. When $x \neq 0, \delta(x) = 1$, else $\delta(x) = 0$. The order quantity in time t is $S_t - S_{t-1} > 0$, and then setup cost is set to A_{t-L} in time $t - L$. Otherwise, it will be 0. Therefore, the setup cost in time t can be described as $A_{t-L}\delta(S_t - S_{t-1})$. Because the holding cost in time t only exist when the total quantity S_t (the order quantity from time 1 to t) exceeds the actual demand, the holding cost can be described as $h_t\max\{0, S_t - (q_1 + q_2 + \cdots + q_t)\}$. Similarly, the backlogging cost in time t only exist when the total quantity S_t (the order quantity from time 1 to t) is less than the actual demand, the backlogging cost can be described as $\pi_t\max\{0, (q_1 + q_2 + \cdots + q_t) - S_t\}$

$$\begin{aligned} E_t(s_{t-1}, s_t) = & A_{t-L}d(s_t - s_{t-1}) \\ & + h_t\max\{0, s_t - Q\} \\ & + \pi_t\max\{0, -s_t\} \end{aligned} \tag{58.4}$$

The cases above apply to when the demand is certain. When the demand is discrete distribution, the following function is applied. The probability distribution of ξ_t is known, and $\xi_1, \xi_2, \ldots, \xi_t$ are mutual independence. The Value Area of $\zeta_t = \xi_1 + \xi_2 + \cdots + \xi_t$ is $\{0, 1, 2, \ldots, nt\}$. According to the convolution formula, the probability distribution of ζ_t can be calculated by the probability distribution of $\xi_1, \xi_2, \ldots, \xi_t$.

$$\begin{aligned} P(\zeta_t = q) = & \sum_{i_1+i_2+\cdots+i_t=q} \prod_{r=1}^{t} P(\xi_r = i_r), \\ & q = 0, 1, 2, \ldots, nt \\ & n = 1, 2, \ldots, H \end{aligned} \tag{58.5}$$

Then the cost model can be described as follow:

$$\begin{aligned} E_t(S_{t-1}, S_t) = & A_{t-L}\delta(S_t - S_{t-1}) \\ & + h_t \sum_{q=0}^{S_t-1} (S_t - q)\, P(\zeta_t = q) \\ & + \pi_t \sum_{q=S_t+1}^{nt} (q - S_t)\, P(\zeta_t = q) \end{aligned} \tag{58.6}$$

Along with the increase of the freezing proportion, three parts of cost's variation trend is shown as follow:

(1) The change setup cost is uncertain. In one hand, the decrease of MPS changes will cause the reduction of the additional cost like the exigency manufacture.

On other, in the period after freezing, it may leave some SR orders, which may cause extra work to finish them.

(2) Following the increase of the freezing proportion, the change of MPS decrease. However, because the uncertain of the demand, enterprises may prepare superfluous inventory in case the demand changes dramatically. Therefore, the holding costs maybe increase.

(3) The backlogging cost maybe increase. If the enterprises do not prepare more safety stock, the backlogging frequency and quantity maybe increase.

When the freezing proportion is 0, the cost is lowest. When the freezing proportion is 1, the cost is highest.

58.2.4 The Service Level Model

The service level means the customer satisfaction rate, namely to customer demand satisfied divide total customer demand. When the service level is 100 %, suggest that all customer needs are met. However, it is very hard to achieve the goal. Therefore, 95 % is set to bottom line of the service level. This paper puts forward the model which not only considers stockout, but also adds the influence of the delay in delivery to service level, and set relevant punish coefficient. Along with the increase of delay time, the punish coefficient increase and the service level decrease rapidly. When delay exceeds the bottom line in the contract, it changes into stockout.

I_t is the inventory in time t, $I_t = SS + S_t^+ - S_t^-$. SS_i is the safety stock in time t. $r_{it} = Q_{it} - x_{it} - I_{it}$, and $r_{it} \geq 0$. Qd_{it} is the quantity of delay in delivery in time t. $\theta$is the punish coefficient.

$$SL(k) = \frac{\sum_{t=1}^{T}\left(\frac{x_t + I_{t-1} + \theta \cdot Qd_t}{x_i + I_{t-1} + r_t}\right)}{T} \tag{58.7}$$

When the freezing proportion increases, service level will decrease. The MPs will not adjust according to the actual demand when it is in the freezing periods. If the customer lead-time is short, the delay may be occurred, even causes stock-out.

58.3 Simulation Procedure

This procedure is improved from Xie's research (Papachristos and Ganas 1998).

Step A: Select, demand variations (Δd), total order variations (ΔQ), production capacity (C). Generate the actual demands and calculate the capacity, then go to step B.

Step B: Select planning horizon (H), setup cost (A_{t-L}), holding cost per unit (h_t), backlogging cost (π_t), freezing proportion (FP), replanning periodicity (RP). Then, go to step C.

Step C: Implement the MPS within the frozen interval, calculate the ending inventories, and update performance measures, then go to step D.

Step D: If the end of the simulation has not been reached, roll the schedule RP periods ahead and go to Step C. Otherwise, record the performance measures and go to Step E.

Step E: If all the combinations of different H, $A_{t-\mathrm{L}}, h_t, \pi_t$, FP and RP have been exhausted, then go to step F; Otherwise, go to step B and select at least one different value of H, $A_{t-\mathrm{L}}, h_t, \pi_t$, FP or RP.

Step F: If all the combinations of different Δd, ΔQ and C have been exhausted, then stop. Otherwise, go to step A and select at least one different value of, Δd, ΔQ and C.

Step G: Combine and compare the performance of overall merits (include instability, costs and service level), then, select the optima.

58.4 Case Analysis

Matlab is used to simulate the procedure and analyze relative result. The result shows that planning horizon (H), freezing proportion (FP) and replanning periodicity (RP) dramatically influence the performance of instability, costs and service level.

58.4.1 The Influence by Planning Horizon

Comparing with performance which PH equals 4 or 8, when PH equals 8, it got lowest total cost, highest service level and instability. Comparing with the researches which do not consider the production capacity, this paper got the same result in known demand condition, but got the different result in unknown demand circumstance (Table 58.1).

Table 58.1 Variables of the experimental design

No.	Variable name	Label	Levels	Values
1	Demand variations	Δd	5	Very low, low, medium, high, very high
2	Total order variations	ΔQ	5	Very low, low, medium, high, very high
3	Production capacity	C	3	Low, medium, high
4	Planning horizon	H	3	4, 8, 12
5	Setup cost	$A_{\mathrm{t-L}}$	3	Low, medium, high
6	Holding cost	$\mathrm{h_t}$	3	Low, medium, high
7	Backlogging cost	π_t	4	Low, medium, high, very high
8	Freezing proportion	FP	5	0.00, 0.25, 0.50, 0.75, 1.00
9	Replanning periodicity	RP	4	0.25, 0.50, 0.75, 1.00 (*H*FP)

When it has the production capacity constraint, longer PH can make the excessive capacity in some periods have more possibility to be used in the period which do not have enough production capacity, which improve the service level and decrease the total cost. In the circumstance which does not have capacity constraint, PH does not influence the service level; the service level is a constant: 100 %. Existing research also do not provide the influence from PH to service level when demand is uncertain and capacity is unlimited.

58.4.2 The Influence by Freezing Proportion

When freezing proportion (FP) gradually increases from 0.0 to 1.0, the service level is gradually decreased and the total cost is gradually increased. This is because when FP is in the lower level, the excessive production capacity of the free periods in this PH can be used in the next PH. The production capacity is fully used, consequently, service level is improved and total cost is reduced.

The FP makes largest influence to MPS instability. When the FP gradually increases from 0.0 to 1.0, the instability reduces rapidly. The result differs dozens of times between FP = 0.0 and FP = 0.75. When FP = 1, all the orders are frozen, MPS will not fluctuate, so the instability decrease to 0. Along with the increase of FP, the free period quantity between two adjacent periods become less and less. Therefore, the re-computation parts are decreased, the instability is also reduced.

58.4.3 The Influence by Replanning Periodicity

From the study results can be seen: when replanning periodicity (RP) is smaller, the total cost is higher, service level is lower, and the instability is higher. This phenomenon can be explained as follows: when RP is smaller, the information got form MPS replanning (using for forecasting) is less, so the MPS performance made from forecasting will not very well. Parts of periods are freezing, therefore, even if more information about demand are obtained, the MPS in frozen parts will not be changed, which is easy to cause the loss. The findings suggest that: in the actual rolling MPS circumstance, it is should try the best to make sure two numbers are equal: RP and frozen period quantity.

58.5 Conclusion

Demand uncertainty and production capacity are limited is the basic characteristics of the production system. The goal of optimize MPS performance is to minimize instability, maximize service, and minimize the total cost. The paper provides an advanced merit which contains all aspects of MPS performance: instability, costs and service level and evaluates in one model. This paper study on the influence from freezing MPS to the overall performance in the assumptions which demand is uncertain; the production is in the same level, the production capacity is existed. The result demonstrates that planning horizon (H), freezing proportion (FP) and replanning periodicity (RP) dramatically influence the performance of instability, costs and service level.

The results got from this paper can guide the product enterprise (both make-to order and make-to-stock), especially the automobile and engineering machinery industry to optimize their Master Production Schedule. The main advantages of the paper are three aspects: first, the established the overall merit of master production schedule based on instability, costs and service level, which consider the performance in freezing mps circumstance. Second, it provides the advanced merit for measuring the instability of Master Production Schedule. Moreover, it is easy to compare the MPS which has least instability. Third, the customer service level factors are inserted the model skillfully, which can help the decision makers to understand which are the bottlenecks of the Master Production Schedule and operation management. It is clear that, the results got from the case study demonstrate the practical applicability of our merit. Therefore, this merit can be used in the actual production situation.

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Chapter 59
The Research of Multiobjective Bottleneck Scheduling Based on Genetic Algorithm

Wen Ding

Abstract In production scheduling more and more scholars are concerned with the handling of bottlenecks, and the actual bottleneck scheduling is a multiobjective problem, and these objectives often conflict with each other. How to balance the different objectives in bottleneck system and realize the multiobjective Job shop scheduling is very worthwhile study. This paper summarizes the existing bottleneck scheduling methods on the basis of literature research, and puts forward multiple objectives production scheduling model based on the single objective production scheduling at the same time to solve the model using the multiobjective genetic algorithm. Examples show that the proposed multiobjective method is more effective than the single in the actual practice.

Keywords Bottleneck · Genetic algorithm · Multiobjective · Scheduling

59.1 Introduction

For any system consisting of a number of related links, the lowest output rate link determines the output level of the entire system. Bottlenecks in the production system have become an important factor. How to deal with bottleneck resource utilization, balance the load, arrange the production task and maximize the production has become one of the production scheduling tasks. More and more enterprises and scholars are concerned about the handling of bottlenecks in production scheduling. The bottleneck scheduling is a multiobjective problem in practice, and these objectives often conflict with each other. How to balance the different objectives in bottleneck system and study the multiobjective Job shop

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scheduling problem is very worthwhile (Sevaux and Dauzere-pere-peres 2003; Koksalan and Burak Keha 2003; Min and Cheng 1999; Wen Ding et al. 2011; Mattfeld and Bierwirth 2004; Park et al. 2003; Chen and Wu 2005).

Through the bottleneck identification, when the bottleneck index less than 0.3, the tasks sorting in bottleneck is to guarantee the capacity of the bottleneck is fully utilized, which ensure the effective output of the enterprise is maximal (Mattfeld and Bierwirth 2004). This paper mainly studies this bottleneck equipment scheduling problem. A single bottleneck scheduling problem is transformed into single device, multitask and multiobjective scheduling problem, and it is necessary to solve the multiobjective function and get the optimal or near optimal solution.

59.2 Single Objective Production Scheduling Function Establishment

In the production practice, people have summarized hundreds of equipment performance indexes and corresponding algorithm on single machine scheduling. Genetic Algorithm (GA) is a kind of intelligent algorithm, and is applied widely in production practice. Here is several production scheduling objective functions.

59.2.1 The Number of Tardy Tasks is Minimal

We define $f_1(\overline{w})$ as the number of tardy tasks, so the problem is transformed into how to arrange a reasonable order for the tasks to minimize the number of the tardy task.

C_i is the completion time of task J_i at any order, and *num* is the number of tardy tasks, *num* is defined as follow: $num_i = \begin{cases} 0, C_i - d_i > 0 \\ 1, C_i - d_i \le 0 \end{cases}$

The target of the solution is to find a kind of arrangement to make $f_1(\overline{w})$ minimal, that is

$$\min num^{\bar{w}} = \min_{\bar{w}\in\Omega} f_1(\overline{w}) = \min_{\bar{w}\in\Omega} \sum num_i^{\bar{w}} \tag{59.1}$$

In the formula, $num^{\bar{w}}$ is the number of tardy tasks under the order $\bar{w}$, $w_i^{\bar{w}}$ is the value of num_i. C_{kJ_i} is the completion time of workpiece J_i on machine M_k, p_{J_ik} express the processing time of workpiece J_i on machine M_k, r_{J_ik} is the buffer time before M_k, δ is buffer safety coefficient, the serial number of machine is: $k = 1, 2, \ldots, m$. C_{kJ_i} is calculated as follows:

$$\begin{aligned} C_{1J_i} &= C_{1J_{i-1}} + p_{J_i1} + r_{J_i,0} \\ C_{kJ_i} &= \max\{C_{(k-1)J_i}, C_{kJ_{i-1}}\} + p_{J_ik} + r_{J_i,k} \end{aligned} \tag{59.2}$$

$$C_i(\overline{w}) = C_{mJ_i} = \max\{C_{(m-1)J_i}, C_{mJ_{i-1}}\} + p_{J_im} + r_{J_i} \tag{59.3}$$

$$r_{J_ik} = \begin{cases} \dfrac{\sum_{g=1}^{k-1} p_{J_ig} + \delta, k \geq 2}{0, k = 1} \end{cases}$$

$$r_{J_i} = \sum_{k=1}^{m-1} p_{J_ig} \tag{59.4}$$

59.2.2 The Total Cost of Task Early and Tardy Handover

The function of earliness and tardiness cost is consistent with the idea of just in time, that is, minimize inventory cost, and meet product delivery. Function $f_2(\overline{w})$ is the minimal value of total cost of early and tardy handover, thus the solution of the problem is transformed into a reasonable order to make the total cost of early and tardy handover.

$$\min_{w\subset\Omega} f_2(\overline{w}) = \min_{w\subset\Omega} \sum_{i=1}^{n} (h_i \max(0, d_i - C_i) + w_i \max(0, C_i - d_i) \tag{59.5}$$

In this formula, n—the number of jobs processed on this machine; d_i—the delivery time of workpiece i; C_i—the completion time of workpiece i; h_i—the early finished cost of workpiece i; w_i—the tardy cost of workpiece i.

59.3 Multiobjective Production Scheduling Genetic Algorithm

In the actual production scheduling, the objective is to find the sorting to meet multiple objectives, but it is difficult to obtain the strict optimal solution, so we only need to find a suboptimal solution or noninferior solution. The following are multiple objectives scheduling functions, $F_w = \min_{w\subset\Omega}\{f_1(w), f_2(w), f_3(w)\}$, Ω—the set of all $J = \{J_{1,}, J_2, \ldots, J_n\}$ arrangement, $n!$—the number of elements, $\overline{w}^*$—the value to minimize the function, i.e. the optimal arrangement.

59.3.1 A Multiobjective Genetic Algorithm

Objectives are often conflict with each other, and there are a lot of Parato optimal solutions in the multiobjective optimization, while policy makers often hope to get more solutions for selection by optimization algorithm. Because of the population parallel search features in GA, the evolution results of GA are a set of solutions, so the GA has become an important tool in multiple objectives optimization.

The target weighting is the most commonly used methods, such as Formula (59.6) shows, and $f(x)$ is used as a GA adaptive value function.

$$f(x) = \omega_1 f_1(x) + \omega_2 f_2(x) + \cdots + \omega_n f_n(x) \tag{59.6}$$

In the formula, ω_i—the weight coefficient, and $\omega_i \geq 0, i = 1, 2, \ldots, n, \sum_{i=1}^{n} \omega_i$.

Obviously, given a set of weight coefficients, the optimization process will move to the Parato border in one direction, and the multiobjective optimal solution doesn't exit in other directions. In addition, many scholars decomposed GA evolution population into several subpopulations which search in different directions with different coefficients. Here is a multiobjective hybrid GA proposed by Ishibuchi and murata.

59.3.2 Multiobjective Hybrid Genetic Algorithm Process

Based on the description above, the multiobjective optimization GA uses the following process (N_p— population size; N_e—the size of the guaranteed optimal solution). Due to the embedding of the local search algorithm, hereinafter refer this GA as multiobjective hybrid GA.

Step 1: randomly generated N_p initial individuals to form initial population.

Step 2: Evaluate the adaptive value of each individual, and update the temporary set of the non-dominated solutions.

Step 3: Repeat the following steps to select the $(N_p - N_e)$ parent populations.

First, generate random weight coefficients by the following formula.

$$\omega_i = \xi_i \bigg/ \sum_{j=1}^{n} \xi_j, \quad i = 1, 2, \ldots, n \tag{59.7}$$

ξ_i—non-negative random number.

Second, select a pair of parent individuals using the roulette by Formula (59.8).

$$p_s = [f(x) - f_{\min}] \bigg/ \sum_{x} [f(x) - f_{\min}] \tag{59.8}$$

$f_{\min}$—the minimal adaptive value in the current population.

Step 4: Select $(N_p - N_e)$ parent individuals from step 3 to perform the crossover operation, and get $(N_p - N_e)$ new individuals, and then perform the mutation operation.

Step 5: Select randomly N_e non-dominated solutions from the tentative collection, and then perform local search process with $(N_p - N_e)$ solutions from step 4, finally get N_p new solutions.

Step 6: Solutions obtained from step 5 become the new current population instead of the original population.

Step 7: If the result of the algorithm meet the criteria, it will terminate, otherwise go to step 2.

59.4 The Application of Multiobjective Scheduling Genetic Algorithm

There are five machines in a resource group. Now there are A, B, C, D, E five kinds of parts need to be produced. The process and delivery time of these parts are shown as Table 59.1.

From literature (Wen Ding et al. 2011), we know that $CR_1 = 0, CR_2 = 0, CR_3 = 0, CR_4 = 0.14, CR_5 = 0$. In the five machines, only M4 is the bottleneck machine, the processing time and the latest finish time are shown in Table 59.2.

The following is the multiobjective GA to solve the above case.

This problem adopts encoding based on operation, each chromosome is composed of $n \times m$ genes which represent operation, and that is, the chromosome is an array of all operation. In this example, heuristic method is adopted to initialize GA. Here, we choose SPT rule, i.e. give priority to the procedure which has the shortest processing time. In the decoding process, firstly, chromosome is regarded as an orderly operating table, then conduct the process according to the table and process constraint process one by one, resulting in the scheduling program.

Table 59.1 The processing sequence, time quota and delivery time

Parts name	Process name and work hour quota (min)					Delivery time
	1	2	3	4	5	
A	M1 12	M3 34	M4 30	M5 30	M2 8	180
B	M2 21	M1 17	M3 25	M4 25	M5 15	120
C	M1 16	M3 20	M2 45	M4 44	M5 30	180
D	M4 24	M5 20	M1 15	M2 20	M3 20	120
E	M3 36	M1 12	M4 48	M2 30	M5 12	120

Table 59.2 The task on machine 4

Task name	Workpiece	Process time	Latest finish time
J1	D	24	45
J2	E	48	78
J3	B	25	105
J4	C	44	150
J5	A	30	142

The adaptive value function is set as: $f(x) = F_{\max} - \omega_1 k f_1(x) - \omega_2 f_2(x)$. GA parameters are selected as follows: $N_p = 20$; crossover probability is 0.8; mutation probability is 0.05; $k = 10$; $F_{\max} = 60$, the whole algorithm termination criterion is set for 15 generation evolution, and the specific process is as follows:

- First randomly generate 20 initial individuals constitute the initial population, and constitute temporary solution set with the non-dominated solutions (Table 59.3).
- Randomly select 17 pairs of parent individuals, and 17 set of weight coefficients.
- Get 17 new individuals by two point crossovers and former insert method.
- Randomly select three non-dominated solutions and 17 new individuals from step 4, then conduct the local search operation using former insert operation as neighbor domain structure, thus get 20 new individuals which constitute a new current population. Then algorithm returns step 2 and repeats the process until the total individual evaluation number reaches to 15. Compared with literature (Liu 2001), the available results and the single objective bottleneck scheduling algorithm result are shown in Table 59.4.

Figure 59.1 shows, using GA to solve multiobjective problem, we can get better results than single objective.

Table 59.3 The cost of earliness and tardiness of every process

Parts name			The cost of earliness and tardiness of every process									
			1		2		3		4		5	
A	Process name		M1		M3		M4		M5		M2	
	C1	C2	0.5	1	0.3	1.2	0.6	1	0.1	0.4	0.7	1
B	Process name		M2		M1		M3		M4		M5	
	C1	C2	0.4	1.2	0.6	1.5	1	2	0.3	0.1	0.4	1
C	Process name		M1		M3		M2		M4		M5	
	C1	C2	0.2	0.5	0.5	1.2	0.3	1	0.1	1.1	0.3	1
D	Process name		M4		M5		M1		M2		M3	
	C1	C2	0.5	0.1	0.3	0.5	0.2	0.5	0.5	0.9	0.6	1
E	Process name		M3		M1		M4		M2		M5	
	C1	C2	0.5	0.5	0.4	0.7	0.2	0.8	0.6	1	0.7	1.2

C1 the unit cost of earliness, *C2* the unit cost of tardiness

Table 59.4 The calculation results of comparison of single objective and multiobjective

	The number of tardy task	The total cost of earliness and tardiness
Goal 1	1	46.2
Goal 2	3	23.7
Multi-goal	2	25.7

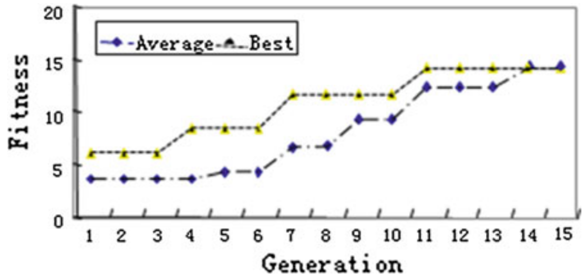

Fig. 59.1 Convergence curves from the genetic algorithm

59.5 Conclusion

In view of single bottleneck and multiobjective production scheduling problem, this paper conduct bottleneck scheduling by GA according to the two objectives: the minimization of tardy task number and the total cost. The example shows that using GA to solve multiobjective problem we can get the better results than single objective.

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Chapter 60
The Study on Multi-Period Procurement of Building Materials Under the Variable Price

Huan Shu and Sheng-qiang Zheng

Abstract According to the characteristics of the material demand in construction field, and based on the method of advancing procurement cross multi-period and storing, the paper gives a multi-period procurement model and the solution method of the building materials under the variable price. The procurement model divides the building materials procurement cycle into several periods by the change point of price and demand rate, and solves the point of purchase and purchase quantity base on each period, it can be applied to the material procurement in construction field well. At last, the paper gives an example analysis of the steel procurement of a project.

Keywords Advance procurement cross multi-period · Building materials · Uneven demand · Variable price

60.1 Introduction

In project construction, the procurement cost of building materials accounts for 60 % of the project total cost (Gao 2011), it plays a decisive role on the profitability of the project. In recent years, the demand and price of building materials are expanding with the rapid development of China's construction industry, this makes contractors face a significant cost risk. So it is necessary for contractors to make an optimal purchasing scheme under the variable price, it can help to control the construction cost risk.

Lev and Weiss (1990) considered the study under the case of price rise and fall is similar. Zhang and Lev (1990) studied the inventory adjustment problem when the price changed twice. After that, Zhang (1997, 1999) studied the multi-period EOQ

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model under the variable price, and he also gave the algorithm. In recent years, the paper of Huang et al. (2003) gave the optimal ordering quantity of Naddor model by solving Cesaro limit of cost-saving function. Sarker and Mahmood (2006) studied the optimal purchasing scheme which can make purchase cost least under the temporary price discounts. Zha and Hua (2007) analysed the temporary additional ordering questions when contractors faced the case of price rise, and they got a calculation model of ordering policy. Mondal et al. (2009) have also considered the inventory model under the variable cost; this model can be applied to solve inventory strategy under the situation of uneven demand.

According to the research methods and results of these scholars, and base on the method of advancing procurement cross multi-period and storing, this paper gives a multi-period procurement strategy and the solution method of the building materials under the variable price.

60.2 Multi-period Procurement Model

60.2.1 Symbol Definition

In the multi-period procurement model,

S_i is the duration of period;
T_i is change time of price, and it is also a boundary point of S_i period and S_{i+1} period;
D_i is the demand rate of materials in S_k period;
A is fixed cost of each procurement;
P_i is the expected price in S_i period;
H_i is storage cost of unit material one day;
$X_{k,i}$ is the number of days that the materials which purchased under the price of P_i can use in S_k period;
M_k is the frequency of purchase in S_k period which base on EOQ model;
t_i is the interval time of purchase in EOQ model;
B_i is an state variables whose initial value is 1, and its value will be 0 when purchasing behavior occurs at the T_i time.

60.2.2 Basic Hypothesis

The multi-period procurement model under the variable price is based on these following hypotheses:

(1) D_i keeps invariant in S_k period, and the demand rate in different period need not be equal;
(2) In S_k period, A, P_i and H_i keep invariant;

(3) The storage cost of material that purchased in S_k period is always H_i until it is put into use;
(4) Does not consider the price information before S_1 period, and the first purchasing behavior also happens in S_1 period.

60.2.3 Multi-period Advance *Procurement Strategy*

According to the research methods and results of other scholars, this paper establishes the following *Multi-period* advance *procurement strategy:*

(1) For the material that S_1 period require, purchase material M_1 times under the price of P_1 and put it into use. Obviously, the purchase cost of S_1 period is determined by M_1. Let the TC_1 (M_1) be the purchase cost, and solve the following objective Function under the limited conditions:

$$\min TC_1(M_1) \tag{60.1}$$

Make the purchasing scheme for S_1 period base on the optimal solution M_1, then the purchase cost of S_1 period can be minimized.

(2) For the material that S_k ($k \geq 2$) period require, it can be divided into two part. One part is the materials that advance purchased in the previous periods; the other part is the materials that purchased in S_k period by several times. Obviously, if the price of the previous periods is lower than enough the price of S_k period, advance procurement cross multi-period is an economical way (Zhang 1997). At the end point of S_i ($1 \leq i \leq$ k-1) period, that is $T_{i,}$ to meet the material demand in S_k (k $\geq$ 2) period, it need purchase amount of material for the S_k period in order to meet the use of the $X_{k,1}$ day, and save them until the period of S_k to use. Across multi-period procurement strategy of partial required building materials in S_k period is shown in Fig. 60.1.

According to the above-mentioned procurement strategy, up to the S_k period, the total procurement materials for the S_k period is $D_k \sum_{i=1}^{k-1} X_k$, which can be used for $\sum_{i=1}^{k-1} X_{k,i}$ days during the S_k period. When all the advanced procurement of materials have been used, if there were material demands vacancy, then the EOQ model of finite horizon can be used M_k times in the S_k period. At the same time, it

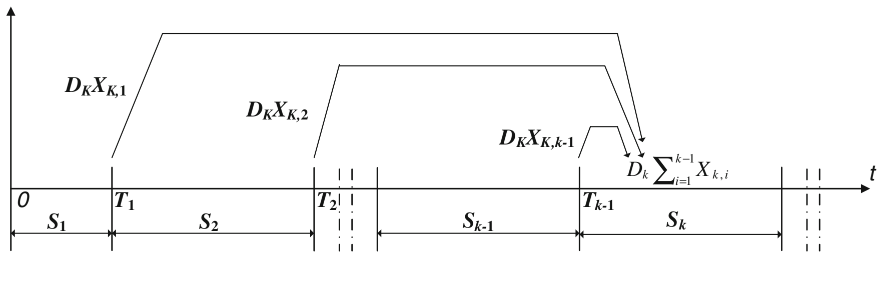

Fig. 60.1 Advance purchase for the material that S_k period require

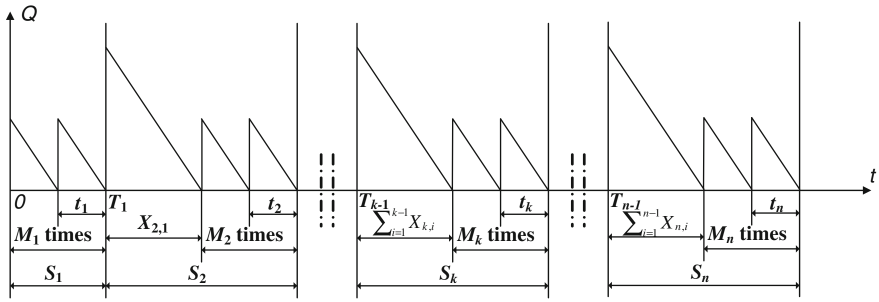

Fig. 60.2 The multi-period procurement strategy in each period

must ensure the procurement just can be run out in the switching time T_k. So far, the required materials in the S_k period have all been purchased, assumed that the cost of the required materials in the S_k period is TC_k ($X_{k,1}$, $X_{k,2}$,…,$X_{k,k\text{-}1}$; M_k), the solution under certain constraints is:

$$\min\left(TC_k\left(X_{k,1}, X_{k,2}, \ldots, X_{k,k-1}; M_k\right)\right) \tag{60.2}$$

It can prepare the material purchasing plan of the S_k period under the target of minimizing material purchasing cost by the optimal solution $X_{k,1}$, $X_{k,2}$, …, $X_{k,k\text{-}1}$. The material procurement strategy in each period is shown in Fig. 60.2.

(3) According to the purchasing strategy, for each switching time T_{i} in every period, the required materials of each following period are possible to buy in advance at T_i. In order to draw the actual total procuring lot at T_i, it needs summarization. In accordance with the above aggregation method, the material procurement planning of the entire planning purchasing cycle is available by summarizing the material procurement planning of each S_i ($1 \le i \le n$) period.

In the view of that material prices P_i in each period is forecasting price, the actual operation should response to forecasting price P_i which constantly updates according to the market changes, then adjust to the following material procurement plan in time.

60.2.4 Procurement Strategy Solving

In the solving process, setting state variable B_i (when the value is 0 or 1, the initial value is 1) expresses whether purchasing behavior happened at the T_i moment. When $B_i = 0$, which said purchasing behavior has happened at the T_i moment, if it need procure in advance at the Ti moment for the following period, then there is no need to repay the single procurement cost A. Depend on the characteristics of the procurement strategy, each period procurement scheme is considered to be independent. As long as the lowest cost of each period procurement scheme can be achieved, then the cost of entire purchasing cycle is minimal. Solution steps are as follows:

Step 1: As there is no consideration of the price before the procurement cycle, the required materials of the S_1 period can take strategy that the current input use the current procurement. Then

$$\begin{aligned} &\min TC_1 = M_1(A + P_1DS_1/M_1 + H_1D(S_1/M_1)^2/2) \\ &s.t. \quad M_1 \geq 1 \end{aligned} \tag{60.3}$$

M_1 is integer

The optimal solutions are M_1^* and TC_1^*, then turn to the solution step 2.

Step 2: Assume that $M_k \geq 1$, that means it need procure some materials to meet the use demand of all materials in the S_k (k $\geq$ 2) period. Then

$$\begin{aligned} \min TC_k = &\sum_{i=1}^{k-1} \left(AB_i \frac{sign(X_{k,i} - 1) + 1}{2} + P_i X_{k,i} D \right. \\ &\left. + \left(\sum_{j=1}^{k-1} S_j - \sum_{j=1}^{i} S_j \right) H_i X_{k,i} D \right) + \frac{1}{2} H_k D \left(\sum_{i-1}^{k-1} X_{k,i} \right)^2 \\ &+ M_k \left(A + P_k D \frac{S_k - \sum_{i=1}^{k-1} X_{k,i}}{M_k} + \frac{1}{2} H_k D \left(\frac{S_k - \sum_{i=1}^{k-1} X_{k,i}}{M_k} \right)^2 \right) \\ s.t. \quad &X_{k,i} \geq 0; \quad \sum_{i=1}^{k-1} X_{k,i} \leq S_k \\ &M_k \geq 1 \end{aligned} \tag{60.4}$$

$X_{k,i}$ is integer

The solution is $X_k = (X_{k,1}, X_{k,2},\ldots,X_{k,k\text{-}1}; M_k)$, and $\min (TC_k)$. If $\sum_{i=1}^{k-1} X_{k,i} = S_k$,then $M_k = 0$, no matter it values, and the optimal solution is $X_k^* = X_k = (X_{k,1}, X_{k,2}, \ldots, X_{k,k-1}; 0)$. Followed that, substituting X_k^* in the formula, the optimal solution is TC_k^*. Turn to step 5. But if $\sum_{i=1}^{k-1} X_{k,i} < S_k$, then turn to step 3.

Step 3: Assume that $M_k = 0$, that means the procurement materials in advance can meet the entire materials use demand of the S_k ($k \geq 2$)period. Then

$$\begin{aligned} \min TC_k' = &\sum_{i=1}^{k-1} \left(AB_i \frac{sign(X_{k,i} - 1) + 1}{2} + P_i X_{k,i} D \right. \\ &\left. + \left(\sum_{j=1}^{k-1} S_j - \sum_{j=1}^{i} S_j \right) H_i X_{k,i} D \right) + \frac{1}{2} H_k D \left(\sum_{i=1}^{k-1} X_{k,i} \right)^2 \\ s.t. \quad &X_{ki} \geq 0; \quad \sum_{i=1}^{k-1} X_{k,i} = S_k \end{aligned} \tag{60.5}$$

$X_{k,I}$ is integer

The solution is $X_k' = (X_{k,1}, X_{k,2}, \ldots, X_{k,k-1}; 0)$ and $\min TC_k'$. Turn to step 4.

Step 4: Compared min $\mathrm{TC_k}$ with $\min TC'_k$ under the assumptions, $M_k \geq 1$ and $M_k = 0$. If $\min TC_k \leq \min TC'_k$, then the optimal solution is $X^*_k = X_k = (X_{k,1}, X_{k,2}, \ldots, X_{k,k-1}; M_k)$,$TC^*_k = \min TC_k$; If $\min TC_k > \min TC'_k$, then the optimal solution is $X^*_k = X'_k = (X_{k,1}, X_{k,2}, \ldots, X_{k,k-1}; 0)$,$TC^*_k = \min TC'_k$. Turn to step 5.

Step 5: According to the optimal solution $X^*_k = (X_{k,1}, X_{k,2}, \ldots, X_{k,k-1}, M_k)$,if $X_{k,i} > 0$, i.e. there is procurement behavior at the T_i moment, then $B_i = 0$, procurement strategy has been solved in S_k period. Then turn back to step 2, it need solve the procurement strategy in S_{k+1} period; Up to $k = n$, i.e. all required materials have been procured, then turn to step 6.

In the solution process, it can use Gaussian function to solve the current procurement lead time t_k in S_k $(2 \leq k \leq n)$, $t_k = \left[\left(S_k - \sum_{i=1}^{k-1} X_{k,i}\right)/M_k\right]$, then divide the remaining time $\left(S_k - \sum_{i=1}^{k-1} X_{k,i} - M_k t_k\right)$ into d_k units(apparently $d_k < M_k$), randomly select d_k units t_k, and on the basis, adding a unit to make it into $t_k + 1$. Similarly, current procurement lead time t_1 in S_1 period can be solved.

Step 6: After all the required materials have been procured in the whole procurement cycle, it need summary the optimal solution X^*_k of procurement strategies in every period, then add all the coming procurement lots at the switching time $\mathrm{T_i}$ in the same period to get the material procurement lots of every purchasing point; At the same time, the procurement cost of the entire procurement cycle can be solved after summarization. Based on the above summarization results, the entire procurement plan and cost can be ensured.

60.3 Application in Procurement of Building Materials

According to the demand characteristic of building materials and application mechanism of the procurement model, it can try to redraw the entire planning procurement cycle with the boundary of price change time-point and demand rate change time-point, and the new period sequence can not only reflect the effect of price, but also guarantee the material demand rate be constant in each period. Assumes that material demand rate has to change at time point e_1, e_2, e_3 and e_4 in S_k period, but the material demand rate of the adjacent time point keeps constant. In order to keep material demand rate of each period (D) be constant, it need take $T_{k\text{-}1}$, e_1, e_2, e_3, e_4 and T_k as the boundary to divide the period into five parts $S_{k,1}$, $S_{k,2}$, $S_{k,3}$, $S_{k,4}$ and $S_{k,5}$. As shown in Fig. 60.3.

It divides the S_i period into several sub-period to get the new period sequence ($S_{1,1}$, $S_{1,2}$, $S_{1,3}$,…,$S_{k,1}$, $S_{k,2}$, $S_{k,3}$,…,$S_{n,1}$, $S_{n,2}$, $S_{n,3}$,…) by using the same principles and methods. Then using the procurement strategy and solving method, it need to solve each period of the new period sequence, and based on the solution and entire purchase cost minimum, to make the building material procurement plan.

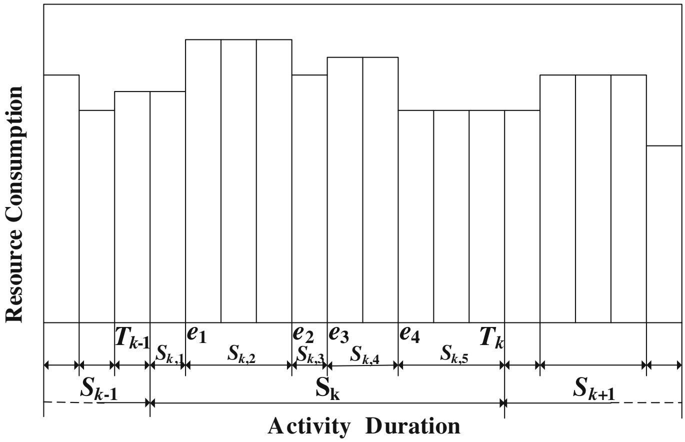

Fig. 60.3 Method of procurement period division for building material

60.4 Analysis of Examples

A project in Nanjing (total building area is 73700 m^2, three individual projects concurrent construct) plan to begin in July 2011, complete in October 2012. This paper takes steel procurement plan of the first four months as example. Based on the prediction method, this paper obtains the steel average expected price from July to October (assuming that the end of month is price changing point), takes the price and demand rate change point as the boundary to divide the period, then the steel procurement period division of the first four months and forecast price of each month can be shown in Table 60.1.

According to "Jiangsu construction engineering cost quota" and something related, a single procurement cost is 300 yuan, inventory cost takes procurement cost 4 %, storage loss rate is 1 %, annual percentage rate is 7 %, and income tax rate is 25 %, then A = 300, $H_i = P_i*(7\,\%*(1–25\,\%) + 4\,\% + 1\,\%)/365$.

Table 60.1 The steel procurement period division

Order number	Period division	Time (day)	Demand (ton)	Price (yuan/ton)
1	2011/7/21–2011/7/31	11	9.2	5046
2	2011/8/1–2011/8/12	12	9.2	5073
3	2011/8/13–2011/8/31	19	10.5	5073
4	2011/9/1–2011/9/7	7	10.5	5118
5	2011/9/8–2011/9/18	11	11.8	5118
6	2011/9/19–2011/9/30	12	11.6	5118
7	2011/10/1–2011/10/5	5	11.6	5147
8	2011/10/6–2011/10/22	17	12.1	5147
9	2011/10/23–2011/10/31	9	11.8	5147

Each period including the first one, the optimal procurement strategy can be solved by using the procurement strategy which has been constructed and the software which use model to solve. The solution is:

In S_1 period, $M_1^* = 2,\ TC_1^* = 506133;$
In S_2 period, $X_2^* = (12;0),\ TC_2^* = 558322;$
In S_3 period, $X_3^* = (13,0;1),\ TC_3^* = 1012533;$
In S_4 period, $X_4^* = (0,0,7;0),\ TC_4^* = 373535;$
In S_5 period, $X_5^* = (0,0,11,0;0),\ TC_5^* = 660796;$
In S_6 period, $X_6^* = (0,0,12,0,0;0),\ TC_6^* = 710932;$
In S_7 period, $X_7^* = (0,0,5,0,0,0;0),\ TC_7^* = 292878;$
In S_8 period, $X_8^* = (0,0,17,0,0,0,0;0),\ TC_8^* = 1056302;$
In S_9 period, $X_9^* = (0,0,4,0,0,0,0,0;1),\ TC_9^* = 547266.$

As for X_3^*, $X_{3,1} = 13,\ M_3 = 1$, indicate that when the price rises, purchasing partial required materials of S_3 in advance is good to reducing the procurement cost; But due to the price increase is limited in S_3 period, the required materials of last 6 days need current procurement.

As for X_8^*, $X_{8,3} = 17$, i.e. the required materials of S_8 period all purchased at the end of S_3 period. Because of the constant rise of material price at that time, the low-price advantage of advance procurement can compensate the holding cost.

As for X_9^*, $X_{9,3} = 4,\ M_9 = 1$, because unit holding cost of partial lead purchase material is more than the saving price margin, it need lead purchase the required materials of the first 4 days at the end of S_3 period, and the materials of the last 5 days need current procurement.

Then the steel procurement plan can be made by summarizing the optimal procurement strategy of each period.

60.5 Conclusion

In this paper, based on the characteristics of building materials, multi-period procurement of building materials under the variable price is solved by using the lead procurement and storage in multi-period. The procurement strategy with the considering of single period, and no requirements of the material demand rate, can be used in the field of building engineering by simple treatment. Finally, taking the steel procurement of a Nanjing project as example, it describes the application process and methods of the procurement strategy in the procurement of building materials.

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Chapter 61
The Exploration of Practice Schema on Clothing Major by Gradual, Divided and Multivariant Way: With Clothing Design and Engineer Major for Example

Xiao-fen Ji, Li-ling Cai and Ying Zhang

Abstract Practice course is an important way to foster college students' manipulating ability and creative ability, students who take part in enterprise practice can help themselves to adapt to future work. This paper pays attention on practice course of clothing major, through the two-way survey on university and enterprise, and then find out the problem on existing practice schema, finally put forward new schema. We hope the application of this new schema improves practice course's effect and quality, embodies the new schema's value.

Keywords Divided way · Gradual way · Practice ability · Practice schema

61.1 Introduction

Off-campus internship is an essential part of practice teaching in higher engineering education, which, is an important way to combine theory with practice. It contributes to the improvement of practice and innovative ability of technology and engineering management major undergraduates. During the practice, undergraduates can deepen the understanding of theoretical knowledge, thus establish a

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solid foundation for future courses study and meet the need of technology and engineering management positions as quickly as possible. Therefore the innovation of clothing practice courses not only has great academic value in practical teaching theory research but also has realistic importance in enhancing the practice ability and promoting employment of undergraduates (Zhu and Yuan 2010; Fang and Shi 2009). Through research we found some problems that practice courses faced with and discussed about the solutions, also introduced a new schema to improve the effect of practice courses.

61.2 Problem Research and Analysis on Existing Practice Schema of Clothing Major

61.2.1 Research Design

Our group designed and implemented two stages of questionnaire survey and interviews. The first stage was mainly through a questionnaire survey and focused on the senior students and previous graduates of clothing major. We distributed 80 questionnaires in total and received 60 valid ones with 75 % efficiency. The second stage was mainly through interviews and focused on the garment enterprises. A total of 16 department heads and managers involved in the face-to-face interviews. A two-way perspective to analysis the settings of the practice courses can lead to more accurate positioning of existing problems, and thus build a more realistic practice schema.

61.2.2 Research Results

The questionnaire survey through the students' perspective showed that most undergraduates have high expectations for internships. Although the high self-expectations had a positive impact on practice effectiveness (Kou 2011), the question is most of them were lack of good psychological preparation and pre-planning. They were often frustrated in the face of the actual working conditions, thereby affecting their initiative. 88 % of undergraduates and graduates were more interested in the practice courses but less satisfied with the practice effects. In the beginning of the internships they were curious and desired to grasp the rich experience and knowledge beyond the textbooks. However, once they entered the enterprise they found that actual production activities were not that easy and the daily production rhythm was quite tight, thus they gradually disgusted with the production and operation-related issues. Also, 75 % of graduates thought the internships were lack of targeted practice. Sophomore stage of the internships is mainly factory tour and observation-based which lack of hands-on aspect and without the technical content. If theoretical knowledge cannot be used to practice, it does not make sense (Zhou and Yang 2007; Pan 2010). Junior stage of practice due to a lack of early guidance and self-planning, undergraduates can easily generate a sense of blindness. 82 % of the graduates reflected their internships were lack of autonomy and with unclear goals. Few of them would made detailed personal plans for the practice courses.

Through the interviews with the managers our research group found the more difficult problem was the matching of practice and the reality of production. In addition, there were a lot of confusions in interns receiving and positions arrangement (Qin 2009). For example, 10 of 16 managers concerned if the internships would disrupt the normal order of production and affect the production efficiency, so they often refused to accept interns in an excuse of produce busy or no time reception. This happened especially to the sophomore interns. Managers believed that the young interns would not be suitable for the specific work, and less job autonomy and objectives (Li 2011; Jiang 2009). In addition, the lack of prior well-organized and detailed planning might bring difficulties for management and control.

In short, the existing practice schema of clothing major cannot fully match the undergraduates' learning ability, cognitive rules and practice expectations. Each stage of the internships does not fully consider the interface between the students' knowledge structure. Second, the specific contents and form are failed to constitute a "seamless connection" with the business operations. In addition, deficiencies in targeted and autonomy of the courses result in unfully mobilized enthusiasm and initiative of the undergraduates, eventually lead to a far cry from the actual effect to the expectations.

61.3 The Exploration of Practice Schema on Clothing Major

61.3.1 Emphasize on a Gradual Process in Learning Practical Knowledge

Internships of universities are quite different from that of college (2 or 3 years). The former focuses on the cultivation of students' operation ability and practical ability (Pu 2008), while the latter pay more attention to the cultivation of students' comprehensive and innovative ability. Therefore clothing major internships should focus on students' comprehensive ability. First, taking the master of theoretical knowledge as the basis of practice, and then deepen the understanding of professional knowledge though practice, thus use the theoretical knowledge and practical experience in innovative applications of expertise. The settings of new practice courses system must emphasize on a gradual way of practical knowledge learning. It would be better to begin with basic theoretical knowledge and make reasonable arrangements for the process, therefore help undergraduates gradually master the theoretical knowledge and practical knowledge, so that they can promote each other.

61.3.2 Emphasize on Divided Projects and Assessment Which Meet a Diversified Requirements of Students

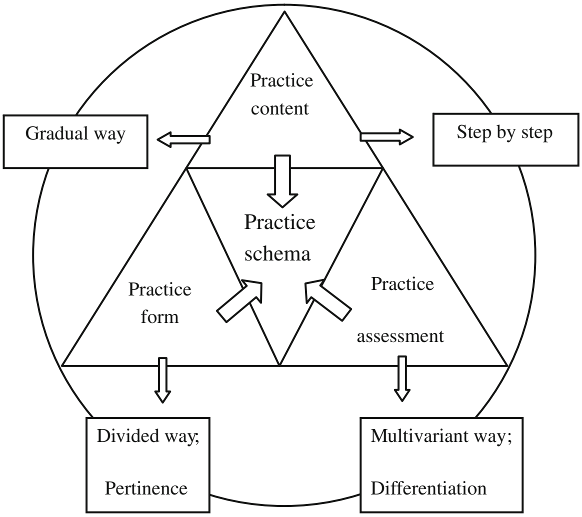
Humanistic learning theory suggests that learners themselves have the ability to learn, the learning process make sense for learners when learning content matches with their purpose (Huang 2009). Internships are an important way for undergraduates to acquire knowledge. Though practice students can not only access to job-related skills (Gault et al. 2000), but also increase professional self-efficacy, and then facilitates the formation of vocational self-concept (Brooks et al. 1995). However, the practice will not achieve the expected effect once the practice mode is not appropriate and the students' interests or purpose go against the practice content. In the recent survey we found that only 10 % of the undergraduates can link current practice with the industry status and future employment, while most of them treat practice as a required courses or practical classes for college, thus the lack of initiative contributes to an unsatisfactory result. Therefore the settings of practice courses must pay attention to students' interest and career choice. The new system must emphasize on the diversified interest requirements of undergraduates and develop a divided internships program and assessment which meet the needs of different specialty.

61.3.3 Practice Schema on Clothing Major by Gradual, Divided and Multivariant Way

According to the research, interviews, and analysis of the key points of setting practice courses, we proposed a practice schema by gradual, divided and multivariant way. In accordance with the principles of gradual and orderly progress, the new schema is supposed to begin with perceptions to stimulate students' interest and curiosity, encourage them to move on to the problem exploration, and then improve and expand professional skills, and finally to the stage of the cultivation of professional skills.

The gradual way emphasize on the comprehension and innovation of theoretical knowledge as well as reasonable arrangements of training period. It forms a step by step learning process which follows a principle from emotional to rational and primary to advance. The divided way refers to the personalization and pertinence of practice schema, namely training students in accordance with individual

Fig. 61.1 Structure and characteristic of practice schema by gradual, divided and multivariant way



differences and carry out the project on reality. The multivariant way refers to the differentiation of assessment methods which suppose to be fair and objective. See Fig. 61.1.

61.4 The Project of Practice Schema on Clothing Major

61.4.1 Practice Content Design

The research group designs three stages of practice content. The purpose of off-campus internships in second year of college is to help the undergraduates recognize and understand the industry and the employees' psychology, ethics and professionalism. Also have a preliminary understanding of the actual situation of production, operation and management of modern enterprises and enhance the theories to acquire more perceptual knowledge.

Internships in third year of college is supposed to apply knowledge and skills to the practical and flexibly solve and deal with practical problems encountered in the process of operational management, such as production technology, product quality and marketing planning. Also they must enhance the problem-solving ability.

In the fourth grade undergraduates should carry out the graduation project while facing the problem of employment. In this period internships can integrate with graduation project. Undergraduates can enhance career self-efficacy through internships and smoothly get to work (Zhang et al. 2009; Zhang 2010).

61.4.2 Practice Form Design

We refine the internships into three stages following the cognition rule and knowledge structure of undergraduates.

First, we propose utilize of inquiry-based practice which is practical-oriented and inspire undergraduates to take the initiative to find the practical problems of enterprise's operation process. Undergraduates would acquire perceptual knowledge of realistic production management and operation conditions through the sophomore stages of practice. At the same time, with their inspection they can find some existing problems in the enterprises, and then think about possible solutions.

In order to strengthen the above capacity, we suggest the form of research projects in the junior stage. Undergraduates will carry out relevant projects and independent proposition based on the topic provide by the teachers in the practice process according to their direction. They must submit the report at the end of the internships. This stage can also be referred to the graduation practice and have greater autonomy.

61.4.3 Practice Assessment Design

Existing assessment method is mainly based on the practice diary and production practice report, partly based on the reviews and discipline of the production practice. This assessment method is so results-oriented that it goes against students' enthusiasm and cannot guarantee the practice effects. In addition, the teacher's assessment criteria may be quite different from the enterprise; it is difficult to balance two of them within the same goal. The practice system can consider both colleges and enterprises (Liu 2008).

Therefore we introduce report and communication section to the assessment criteria. The specific approach is: both undergraduates and the corporate staff participate in the communication meeting in the guidance of the teacher at the end of the internships. First, undergraduates report their experience; then, on-site students and teachers are free to ask them questions; finally, corporate staff and teachers give a score considering the performance of the undergraduates, including their performance in the internships. The final score should be based on the undergraduate's understanding of the position, the actual practice performance and the ability to identify and solve problems (Table 61.1).

Table 61.1 Details of practice schema by gradual, divided and multivariant way

Stage	Skills	Capacity	Form	Assessment
Second	Basic	Perspective ability	Question-oriented	Communication meetings;
Third	Specialty	Practice ability	Project-oriented	Discipline;
Forth	Professional	Innovative ability	Independent proposition	Company reviews; Practice report

61.5 Key Points of the Application of New Schema

61.5.1 Arousing Practice Enthusiasm and Initiative

It is not easy to apply and promote the practice schema by gradual, divided and multivariant way. The primary problem which is quite critical in the second year of college is how to stimulate the practice enthusiasm and initiative of the undergraduates. To this end, excellent graduates should be invited to give lectures early of the practice. Details of communication including: organizational form of internships, difficulties in the practice, issues should be taken care and suggestions on the choice of internships positions. Also, clothing business managers can be invited to give some introductions about the positions, including: working environment, work processes, basic quality and specific requirements of different positions, salary comparison, and future development of different positions. According to our experience in the practice training courses, these measures have good guidance and inspiration for students and help students to set the right goal in practice, thus to arouse the enthusiasm of students to initiatively plan and actively participate in the internships.

61.5.2 Monitoring and Making Objective Evaluation of Student's Practice Process

Internships are a self-learning process and are mostly conducted dispersedly. However, the practice courses often go into an awkward situation that the learning process is difficult to control and the effects are difficult to compare. To solve this problem, we designed a practice process management approach relying on the practice network platform for the relevant functions. For example, students involved in internships are required to register basic information (daily practice arrangements, basic information of the teacher, e.g.) to enable teachers to keep abreast of the progress of internships; In addition, students need to upload internships diary and practical report regularly so teachers are able to make a comparison of the process according to the complementation speed and quality of the process results. Such a schema not only contributes to the achievement of the objective and comprehensive assessment of the practice courses but also arouse the initiative and enthusiasm of the students to participate in internships.

61.6 Conclusion

Off-campus Internship is an important way to enhance comprehensive ability, practical ability and innovative ability. It is an essential practical course in project management major. We pointed out several problems and deficiency in existing practice courses of clothing major though questionnaire survey and interview analysis of both colleges and enterprises, and then putting forward a new practice schema by gradual, divided and multivariant way including the structure, content, form, assessment method and key points of the application of the new schema. The new practice courses and the production and theory courses would complement each other so they can help students to acquire more comprehensive knowledge of the industry. Practice schema on clothing major by gradual and step by step way has received the national teaching awards in 2009 as an important son achievement, and, the group will move forward to explore and reform the practice courses which meet the acquirements of undergraduates, colleges and the industry.

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Chapter 62
Study on Modular Teaching Mode for the Course of Advertising Design Basis

Yan-feng Xu

Abstract Advertising design basis is an important foundation course for the students major in advertising design. Because of the wide range of the content of the courses, teachers need to integrate a good deal of rudimentary knowledge and innovate continuously. On the basis of analyzing the necessity of implementing modular teaching, this paper divides advertising design basis into module of composition basis, graphic creativity, color design, text design and layout design. At last the paper puts forward the problems needs to solve during the process of implementing modular teaching.

Keywords Advertising · Design basis · Modular

62.1 Introduction

Advertising design basis is an important professional basic course for the second grade students majoring in advertising design. The course introduces the basic elements of advertising design and their application, guides the students to understand the basic methods of advertising design. The course plays very important role in cultivating the student's professional quality, professional interest and design consciousness.

With the development of science and technology (Liu 2000), the adman needs to master the latest knowledge, which puts forward higher request for the

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education of advertising design, namely, to cultivate students' ability of integration and innovation. Modular teaching mode can introduce the thought of innovative design into advertising to cultivate advertising talents adapting to market.

62.2 Necessity of Modular Teaching Mode

62.2.1 Need of Advertising Teaching

As a professional basic course, the contents of advertising design basis are very wide. Modular teaching can disintegrates the contents into different modules, which makes it easy to adjust the course. The modular design of the curriculum changes the inherent closure defect of traditional course unit. The modular design integrates the contents, which have inner logical connection. It shows both comprehensive of knowledge and the opening characteristic of teaching method.

62.2.2 Meet the Demand of Society and Market

In recent years, demand for practical skilled talents has been increasing (Du and Cui 2008). Since most of the graduates' comprehensive quality can not reach the requirement of social employment, which leads many students to the embarrassment of unemployment after graduation. Situation of students majoring in advertising design is not optimistic. Modular teaching can cultivate practical talents, who can adapt to work quickly after graduation.

62.2.3 Combining Theory with Practice

Based on theoretical knowledge, corresponding design practice training is added in each module of the course. The design work is criteria to test students' practice ability, which has the distinct characteristics and maneuverability. Modular teaching mode can put the theory into practice in the shortest time, which can turn the student quickly to the actual combat talent.

62.3 Module Design of Advertising Design Basis Course

According to the course, five modules are designed. They are composition basis module, graphic creativity module, color design module, text design module and layout design module (as is shown in Table 62.1).

Table 62.1 Module design of advertising design basis course

Module	Content of the module
Composition basis	(1) Two dimensional composition; (2) Color composition; (3) Three-dimensional composition; (4) Actual combat training
Graphic creativity	(1) The classification of graphics; (2) Creative thinking of graphics; (3) Creative method of graphics; (4) Actual combat training
Color design	(1) Psychological feeling of the color; (2) The symbol and use of color; (3) Application examples of color; (4) Actual combat training
Text design	(1) Copy scheme; (2) Lettering; (3) Application examples of font; (4) Actual combat training
Layout design	(1) Aesthetic principles of composition; (2) Basic form of advertising arrangement; (3) Actual combat training

62.3.1 Composition Basis Module

The composition basis module includes two dimensional composition, color composition and three-dimensional Composition. The composition design has been the most basic foundation course for college students since Bauhaus. Through the strict visual training, the students can grasp design rules and understand the basic design principles of visual art. The rationality of composition course can inspire students' potential talents and imagination, which can liberate the creativity of students to do design.

62.3.2 Graphic Creativity Module

Graphic is one of the most important factors of advertising, which has strong ability to attract attention (Xu et al. 2006). Good graphic design can communicate without word. It can break through the language barrier and fusion cultural differences (Strong 1925). Due to their respective life practice and the major effect of the artistic accomplishment, creative methods of different designers have their special features, but there is still common law to graphic creativity. Therefore, the graphic creativity is taken as an independent module. Through the research on the laws of graphic creativity, the student can master the commonly used methods, such as isomorphism and deconstruction, composite and mutation. Students are encouraged to reflect the established advertising subject by creating different visual graphics to lay a solid foundation for the following advertising professional design.

62.3.3 Color Design Module

Color has a strong expression, which is the important prerequisite to produce visual impact and artistic appeal (Homer and Yoon 1992). Performance of graphics and text depends on color in advertising. It is one of the important factors to catch the audience's attention (Michael 1982). On the basis of color composition, color design is taken as a separate module. Through the training of color design, the students can not only symbolically display specific advertising theme by color, but use the cooperation of various kinds of color to produce perfect artistic effect according with the characteristics of the advertising.

62.3.4 Text Design Module

Text has the functions of information spreading, persuading and deepening our memory. The graphic and text should cooperate closely in the advertising design. In text design module, through the study of copy scheme, students can write persuasive language according to the advertising theme and creative requirements, which can convey the information of product and enterprise to the consumer directly. Through the study of lettering design, the students can choose or design the fonts to strengthen advertising visual effect.

62.3.5 Layout Design Module

Layout design module is the module of integration (Yu 2000). Through learning of aesthetic principles, students can use the rules to analyze and judge the aesthetic feeling of various visual images, and can apply them to advertising design. Through the study of the compositions commonly used, students can choose the appropriate layout according to the needs of the advertising theme.

62.4 Implementation of the Modular Teaching

62.4.1 Strengthen Teacher's Modular Teaching Consciousness and Ability

The implementation of the modular teaching needs teachers' changing of their ideas to break the routine of the complete course system and integrate relevant knowledge to a module. The teachers need to understand the course systematically, comprehensively and thoroughly. At the same time, the design practices of each module need the guidance of teachers, which is a great challenge for teachers' actual operation ability.

62.4.2 Perfect the Laboratory with Software and Hardware Equipment to Ensure the Development of Modular Teaching

One of the characteristics of modular teaching on advertising design basis course is the combining of theory with practice to cultivate skilled talents. The method emphasizes the practice ability, which asks students to complete the corresponding design practice on the basis of theory knowledge. Special design needs support of software and hardware in laboratory.

62.4.3 Establish Scientific Achievement Evaluation System

The implementation of modular teaching makes it reasonable for the teachers to grade the students not only by the traditional final grade, but the achievement of each module and students' characteristics should be taken into consideration, either. Therefore, teachers should draw up a score standard for each module in advance and carry out seriously and practically. Only in this way, can the method achieve the expected purpose and result.

62.4.4 Combined with the Enterprise's Actual Design

In order to improve the teaching quality of modular and enhance students' enthusiasm to participate, we can establish cooperation relations with some enterprises. The students can participate in the subjects of the enterprises, while related personnel of the enterprises can engage in the teaching and design. In the end, the mature works can also put into use.

62.5 Conclusions

Advertising design is a comprehensive subject. Modular Teaching Mode can not only supply the teaching with new knowledge and new technology, but enhance the suitability of the content greatly. Modular Teaching Mode can adapt to students of different learning basis, strengthen students' learning enthusiasm and cultivate students' creative consciousness and professional sensitivity to a certain extent. As noted, The implementation of modular teaching on advertising design foundation course needs the in-depth cooperation of teachers and students, which puts forward higher request for both the teachers and students.

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Chapter 63
Strategic Selection Based on Industry Environment Analysis: Case Study on Ningbo FOTILE Kitchenware Co., Ltd.

Shuang-shuang Shi

Abstract As we all know, strategy comes into being for the aim of dealing with fervent competition successfully. Nowadays, as the competition within and between all trades is becoming incessantly fierce, it is a prerequisite for enterprises longing for success to make the right strategic selection to triumph over others in the competition. In the kitchenware market, Ningbo FOTILE Kitchenware Co., Ltd. has become the leading brand in range hood manufacturers over ten-year efforts. This essay aims to analyze how enterprise could become the champion of competition aided by strategic selection, through the analysis of the status quo of the kitchenware industry, the history of Ningbo FOTILE Kitchenware Co., Ltd., the industry environment analysis on kitchenware industry and the strategic selection of FOTILE.

Keywords Competition · FOTILE · Kitchenware · Strategy

As is known to all, human beings cannot survive without four basic necessities of life, namely, food, clothing, shelter and transportation, among which food is given the primary priority. With the ever-improving material living standard, families tend to attach more attention to the living quality, which makes the improvement of living quality a hot topic. This attention catalyzes the rapid development of kitchenware market, as kitchenware is of great importance to deliver delicious cuisines.

63.1 The Status Quo of Kitchenware Industry

Kitchen industry has completed a qualitative change stage from rapid growth to gradually mature period since 1980s (Wang 2007). In recent years, China's kitchenware market keeps a momentum of 35 % increase, and its annual turnover

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reaches almost 10 billion RMB. The number of domestic kitchenware manufacturers has increased unprecedentedly to 1,000 (Zi 2005). On one hand, the kitchenware industry faces an idea opportunity for development, on the other hand, with the limitation of technology, production capability and brand influence of kitchenware industry, the industry sinks into a chaotic state due to the uneven distributions of quality among the different products (including range hood, hob, disinfection cabinet, dishwasher, microwave oven cupboard and so on), which inhibits the rapid and healthy development of the industry as a result. In 2006, the overall Chinese household electric appliances amount to 650 billion RMB, mobile phone (24.6 %), IT (15.1 %), color television (13.9 %) duly ranking the top 3. The 4th is occupied by small household electric appliances with preponderance of kitchen appliances, which seizes 11.7 % of the total, or 76 billion RMB (Zhao 2009).

Domestic kitchenware industry, especially the rang hood one, has a history of more than 20 years and has went through three phases, from modeling, R&D to maturity, types evolving from under-cabinet hoods, chimney hoods to Island hoods (Zi 2005). Different from large-scale household electric appliances market, the kitchenware market is almost fully occupied by Chinese brands before 2002. At that time, available foreign brands are mainly oriented to the high-end market, rare and costly (Zi 2005). While at the year of 2002, as the purchasing willing of consumers in full set of kitchen appliances surges, the market margin expanses and its lucrative potential lures large international manufacturers such as Electrolux (Switzerland), Simens (Germany) and Panasonnic (Japan), stepping into the Chinese market. Meanwhile, domestic manufacturers such as Haier, Kelon and Midea follow suit, investing heavily on kitchenware industry. Besides, a number of emerging private small-and-medium-sized enterprises take an active part into this market, realizing the prosperous profits and the relatively low requirement for technique and cost of production. Therefore, the domestic kitchenware market is in chaos, with more than 400 manufacturers and nearly 300 brands.

However, despite of the chaotic situation, it generates a group of spearheads in respective areas of kitchenware appliances, such as Sacon and Fotile in range hood, Vatti and Guangdong Micro in hobs, Gelanz in microwave oven. In this essay, the discussion is based on case study of FOTILE, to address how to obtain advantageous status and sustainable business development under such a fierce competition with nearly 1,000 enterprises to share the kitchenware market margin.

63.2 The History of FOTILE

Mao Li-xiang, the funding father of Ningbo FOTILE Kitchenware Co., Ltd., embarked on his own business more than 20 years ago. In 1985, when township enterprises started to implement appointment system for factories directors in order to select capable candidates adept at management as chief in charge, a group of audacious township entrepreneurs full of market-pioneering spirit came to the fore. Mao commenced his first enterprise for Cixi wireless Electricity Plant IX, lighting up his career with electric lighter (Zhang 2003; Chen et al. 2011).

Mao conceived the idea of turning to another trade triggered by a crisis in 1994. At that year, *Feixiang* Group, the winner for sixth consecutive years in sales volume worldwide, even confronted by pernicious price war among electric lighter manufacturers, suffering a disastrous loss, Thinking of his talented son, he started his second enterprise together with him, Mao Zhong-qun, as the old Chinese saying going, "Fighting a tiger with dear brother and fighting a war with father increase your chance of triumph". They cofounded FOTILE Group, the precursor of the FOTILE Kitchenware Co., Ltd. renamed in 1996, marching on the range hood industry. Although FOTILE is the last entrant when compared with Vatti and Sacon, it quickly occupies the second place in the market (Wu and Li 2005).

Since its foundation, FOTILE Kitchenware Co., Ltd. has been focused on the R & D and manufacturing into high-end built kitchen appliances and integrated kitchenware, devoting itself to providing people who are craving for superb living standard with kitchen electric appliances leading in design, humanistic in technology and excellent in quality. The high-end integrated kitchen brand "BIRCCI" and professional brand for household water heater system "MIBOI" are the epitomes of FOTILE's products. Through 15 years' efforts, FOTILE has ascended to the No. 1 in domestic high-end kitchen electric appliances market, maintaining its status as No. 1 in the high-end market with the lion's share (in terms of both the value and volume of its sales). At present, FOTILE has more than 7,000 staff nationwide in FOTILE, with excellent army of designers from home and abroad, those internationally renowned designers mastering the production facility and state-of-the-art technology for Germany and Italy imported high-end kitchen appliances. In 2008, FOTILE relocates itself to FOTILE Binhai Industrial Park (with an area of 400 mu), Hangzhou Bay Area, where FOTILE will continue to spare no effort for its highest mission of "the No. 1 brand in high-end built-in kitchen electric appliances in China" (Zhao 2009).

63.3 Industry Environment Analysis on Kitchenware Market and FOTILE's Strategic Selection

Industry structure and competitive strategy are keys to profitability. As Michael Porter points out, the first step in structural analysis is an assessment of the competitive environment in which the company operates—the basic competitive forces and the strength of each in shaping industry structure (Porter 1980). So in this part, we will analysis FOTILE's industry environment and strategic selection.

The competitive intensity of an industry is determined by five basic forces (As shown in Fig. 63.1), those forces cooperating with each other to determine the overall industry profitability with enormous influences on all the enterprises in the same industry (Porter 1979, 1997; Miu 2007). In essence, the job of the strategist is

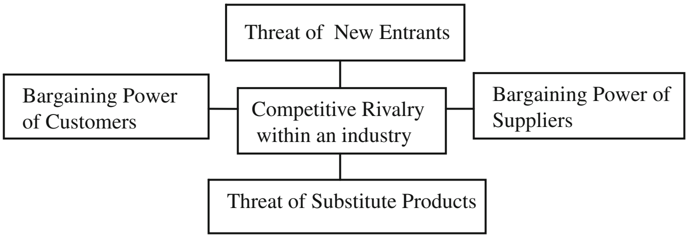

Fig. 63.1 Porter's five forces analysis

to understand and cope with competition (Porter 2008). In order to deal with these competitive forces properly, strategic-decision makers must penetrate the sources of each force thoroughly. Industry profitability is generally determined by the most competitive force or several, each competitive differing in degree of importance. For instance, a leading enterprise in an industry is prone to be threatened by a competitive new entrant with declining revenue as a result, when there are no other products in higher quality and lower price. In that case, the first priority lies in how to take appropriate measures to address the competitive new entrant.

63.3.1 Threat of New Entrants

Potential entrants can reduce the existing enterprise's profit in two ways: First, Entrants will carve up the original market and then share some business; Second, entry minus market concentration so as to arouse competition between the existing enterprise and reduce their profit (Yang and Li 2005). As it is mentioned above, new entrants are engrossed by the booming kitchenware market need, the average lucrative profits and the relatively low requirement for the technique and cost of production, anticipating a stand and share in the attractive market to bring competitive resources for their sustainable development. Undoubtedly, their entrance will generate a new wave of production energy and accelerate competitiveness, which has the potential to threaten the "spearheads" within the industry. Hence, it is of significance for leading enterprises to avail themselves of their status to fortify the entrance barriers in the industry.

FOTILE holds more than 300 top patent technology with 30 patents for invention, and pays close attention to the accumulation and preservation of knowledge and patent over a long term through more than 5 % of total revenue into R&D. According to the statistics provided by National Patent Bureau, FOTILE ranks No.1 in patent application in kitchenware industry, its application amount at more than 100 % year-on-year increase. For new entrants, the scale economy generated by the technology, R&D capability and the incessant financial investment is beyond compare.

Over a long time, brand-oriented FOTILE has been putting its unique perception of Chinese kitchen and Chinese kitchen culture into its design and R&D, and combining marginal science such as human engineering and aesthetics with technology to create the most suitable kitchen appliance tailored to China's current kitchenware market. Brand awareness, brand loyalty, and pre-purchase rate all come out first. This high degree of brand recognition erects a high barrier for new entrants to break down at a high cost as entrance fee. Even those entrants with abundant reserves, they are unable to build their brand loyalty in a day.

Persisting in independent development, FOTILE is willing to conduct open cooperation, and has been cooperated with first-class enterprises worldwide such as SASAFU, Schott Glaswerke, Microsoft and UFIDA Software. The establishment and management of logistics and distribution system bring huge benefits to sales. Through years of improvement and revolution in management, FOTILE obtains and maintains distinguished competitive advantages, and consolidates further achievement in core competitiveness.

From the analysis above, despite the easy access to kitchenware industry and the lowered barriers by low requirements on technology and production cost, FOTILE builds a higher access barrier different from the average of the industry through its competitive advantages by rare, valuable and inimitable strategic resources such as scale economy, brand and reputation, and sales channel.

63.3.2 Demanding Consumers and Suppliers

For members inside an industry, suppliers can improve bargaining power through raising price or lowering purchase volume and service quality, while consumers can beat down the price, demanding higher product and service quality (Porter 1979). Generally speaking, enterprises can improve their strategic situation from suppliers or customers who post the minimal impact on them. Most commonly, enterprise has a say for the target of products, that is, for choosing customers.

For FOTILE, covering a wide rang of customers with different background, age, cultures, habits and occupations such as gourmet, businessman, scholar, doctor, lawyer, and artist to name a few, all its customers have one thing in common that they have a demanding for superlative life and are perfectionists who love live fervently and think independently. Like its customers, FOTILE advocates Thatcher-way of success: at work, they are supreme leaders; off work, they are people who appreciate the art of cuisine. All these people manage their family life exactly the way they manage their career, as they firmly believe that the true successor must be a master at the balance between work and life.

So far, FOTILE focuses itself on high-end kitchen electric appliances, adheres to the idea of first-rate, superb quality and uniqueness in product development with more than 5 % of total revenue into prospective R & D, and keeps upgrading products to satisfy the ever-changing customer needs. When confronting demanding customers and lower price by fierce competition, FOTILE's CEO, Mao

Zhongqun, always comments, "The market has its inherent product positioning and price positioning since the very beginning, dividing customers into several corresponding groups. We position FOTILE at the high-end; therefore lowering the price equals lowering product positioning." While encountering international household magnate Simens' entrance, headed by Sacon, ROMAM and Vatti, most domestic brands choose to lower their price as the countermeasure to drag their customers back. In the short term, this measure could maintain or increase market share a little, while in the long term, it will encroach enterprise's own profit margin, meanwhile crippling product class and comprehensive competition strength. Through efforts from technology, quality and service improvement, FOTILE preserves and even increases sales price to some degree, and succeeds in maintaining its market share (Cai 2008).

It is what FOTILE has chosen as strategic selection makes what it is now. Today, although being much more expensive than foreign brands in price, FOTILE still exceeds them in sales; this best testifies FOTILE's strategic selection.

63.3.3 Substitute Products

Substitute Products or Services (addresses as "Product" below) refers to alternatives through improvement in quality and price to replace their predecessors. They will influence current products and services more or less. Substitute Products usually plunge into the market with a wave of lower price or improved function, when there is aggravated competition impelled by development. FOTILES is quite an expert in this aspect. By conducting elaborate market research and cooperating with Zhejiang University Industrial Design Department, FOTILE succeeds in designing and developing the kitchenware appliance in accordance with Chinese market reality. The first FOTILE artificial intelligent range hood, the first FOTILE automatic gas water heater and the first FOTILE disinfection cabinet combining high ozone technology with high ultraviolet technology are all specified to the features of Chinese kitchen (Zhao 2009).

Therefore, one of the survival strategies in kitchenware industry is product innovation. Making a breakthrough from the current and obsolete products, an enterprise should penetrate new market based on consumer needs, and then rely on product innovation with technology innovation as the core so as to achieve the tremendous transition from manufacturing to creation. Only by the accomplishment of such a transition can an enterprise be able to satisfy the various customer needs through new products and reduce the threat brought by substitutes to the minimum.

63.3.4 Competitive Rivalry Within an Industry

As above-mentioned, kitchenware market is in such chaos with more than 400 manufactures and nearly 300 brands. The intensity of competitiveness is obvious to all. As we know, the competition to seize advantageous position among current rivalries will compel enterprises take strategies like price competition, new product, and advertising war.

Compared with domestic household names such as Vatti and Sacon, FOTILE is the latest entrant in kitchenware market. With Ms. FOTILE's frequent appearance on the screen, FOTILE's rang hoods enter into thousands upon thousands families. Relying on product innovation, technology innovation, marketing innovation, management innovation, brand innovation and culture innovation, FOTILE stands out among competitors; on humanized professional kitchen technology, fashionable design, excellent quality and improved service system, it becomes the spokesman of Chinese kitchen culture, advocator of new life style and kitchen expert among consumers.

63.4 Conclusion

This paper takes Ningbo FOTILE Kitchenware Co., Ltd. as an example, introduce the kitchen industry's industry environment analysis and FOTILE's strategic choice for the enterprise, in order to analyze how to be big winners in the industry by the strategic choice. In fact, not kitchenware industry alone but all trades have to deal with above-mentioned competitive forces, as they are components of Industrial Organizational economics. The strategic decision makers should design the action plan after taking all these influential competitive forces into serious evaluation, including: positioning the enterprise properly to optimize all the available resources and talents, anticipating the changes in the elements inside all the competitive forces, and making the appropriate strategic action plan, and so on.

All in all, if an enterprise wants to establish a foothold in an industry out of cutthroat competition, it has to make it through various ways, neither being easily shattered by the current or new rivalries' frontal attack, nor being crippled by demanding suppliers, buyers or substitutes (Porter 1979).

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Chapter 64
Research on Control Scheme of Coordinate Data Based on Multivariate SPC

Zhen Shen, Yi-hai He, Kai Mi and Chun-hui Wu

Abstract Coordinate measuring instruments are used broadly in quality monitoring of automatic manufacturing, which usually generate three dimensional coordinate data (vector data). That traditional SPC focused on scalar data monitoring causes a great loss of data information and increases the second error probability of statistical process control easily. Thus it becomes more important to monitor coordinate data rather than scalar data in order to implement dimensional control. In this paper the coordinate monitoring method in manufacturing process is proposed. Multivariate statistical process control(MSPC) are used to build the monitoring scheme and the details of monitoring three basic geometrical elements, point, line and plane, are discussed. Performance of traditional SPC and the new proposed control scheme are compared. Research results show the second type of error probability of the presented control chart is smaller and it has more operating validity than the traditional control charts through a numerical example of vector dimension data.

Keywords Coordinate data monitoring · Dimensional control scheme · MSPC · Quality control

64.1 Introduction

As the automation degree of modern manufacturing process has becoming more and more high, automated coordination measurement machines are widely used. The traditional statistical process control chart techniques (Zhang and Liang 2009; Jin and Tsung 2009) focus on scalar data and result in great data information loss

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and increased second error probability. This can not meet the modern high quality manufacturing process quality control requirements.

Therefore, dimensional control method research has become a new hotspot of SPC field. Chen and Nembhard (2011) proposed a Multivariate Cuscore (MCuscore) SPC procedure based on the sequential likelihood ratio test and fault signature analysis. MCuscore SPC is developed for monitoring the mean vector of an auto-correlated multivariate process.

In many situations, the quality of a process may be better characterized and summarized by a relationship between the response variable and one or more explanatory variables. Profile monitor (Woodall 2007) is proposed to model the relationship of vector and scalar dimension, and many researches have been applied in Statistical Process Control (SPC). Woodall et al. (Mahmoud et al. 2007; Woodall et al. 2004; Kim et al. 2003; Williams et al. 2007) gave an introductory overview of the emerging field of profile monitoring. Hosseinifard and Abdollahian (2010) proposed a supervised feed forward neural network to detect and classify drift shifts in linear profiles.

In order to reducing the high second error rates of traditional multivariate control charts (Shu and Tsung 2003; Zou et al. 2006, 2007) monitoring the vector dimension, this paper will propose the coordinate monitoring method in manufacturing process. Multivariate statistical process control are used to build the monitoring scheme and the details of monitoring three basic geometrical elements, point, line and plane, are discussed. The Sect. 64.2 expounds the details of the new monitoring scheme. Section 64.3 studies the performance of the proposed monitoring method. In Sect. 64.4 a numerical example of coordinate data monitoring method is put forward. Finally a conclusion is made.

64.2 Quality Characteristic Vector Control Scheme

Usually, we take three geometrical elements point, line and plane of constituted parts to describe part dimension in vector space. Two different points form a line; three points which are not in a line can constitute a plane. For a point can be seen as a special case of a line (two endpoint of the line are coincident), therefore, the control scheme of line is the key to establish the systemic control means of coordinate dimension.

64.2.1 Coordinate Data Monitoring of Line

We use three dimensional coordinate to show the space position of a point, namely a point X_i in space which can be represent by coordinate (x_i, y_i, z_i). As two points constitute a line, it needs at least two points to monitor a line. A line L_i in space can be represented by coordinate $(x_{1i}, y_{1i}, z_{1i}, x_{2i}, y_{2i}, z_{2i})$ (x_{1i}, y_{1i}, z_{1i}) and

(x_{2i}, y_{2i}, z_{2i}) stands for starting point and endpoint coordinate, especially $((x_{1i}, y_{1i}, z_{1i}) \neq (x_{2i}, y_{2i}, z_{2i}))$.

If monitor p lines,

$$L = \begin{pmatrix} (x_{11}, y_{11}, z_{11}, x_{21}, y_{21}, z_{21}) \\ (x_{12}, y_{12}, z_{12}, x_{22}, y_{22}, z_{22}) \\ \vdots \\ (x_{1p}, y_{1p}, z_{1p}, x_{2p}, y_{2p}, z_{2p}) \end{pmatrix}$$

When process keeps in control, the mean vector is $u = (\overline{x_1}, \overline{y_2}, \overline{z_1}, \overline{x_2}, \overline{y_2}, \overline{z_2})$ and covariance is

$$S = \begin{pmatrix} s_{x_1x_1} & s_{x_1y_1} & s_{x_1z_1} & s_{x_1x_2} & s_{x_1y_2} & s_{x_1z_2} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ s_{z_2x_1} & s_{z_2y_1} & s_{z_2z_1} & s_{z_2x_2} & s_{z_2y_2} & s_{z_2z_2} \end{pmatrix}_{6\times 6}$$

Usually, the process u and S are unknown, we use statistic T^2 about the mean vector to monitor these lines.

$$T^2 = n(\overline{x} - u)' S^{-1} (\overline{x} - u) \tag{64.1}$$

In expression (64.1), $\overline{x}$ is the sample mean of p variables from each batch of sample in size n. $(\overline{x} - u)$ is p dimensional vector, S is sample covariance matrix. Estimation of u and S could be made that.

$$\widehat{\mu} = \overline{\overline{x}} = \frac{1}{m} \sum_{j=1}^{m} \overline{x}_j, \widehat{S} = S_p = \frac{1}{m} \sum_{j=1}^{m} S_j$$

where $\overline{x}_j$ stands for jth subgroup mean vector, S_j stands for jth sample covariance matrix.

Thus we have

$$T^2 = n(\overline{x} - \overline{\overline{x}})' S_p^{-1} (\overline{x} - \overline{\overline{x}}) \tag{64.2}$$

When the actual distribution center is u, statistic $\frac{n-p}{p(n-1)} T^2$ obeys F distribution which first freedom degree is P and the second freedom degree is n-p, that is $\frac{n-p}{p(n-1)} T^2 \sim F_{p,n-p}$.

Take the false report probability as α, the upper limit of multivariate T^2 control chart is

$$UCL = \frac{p(n-1)}{n-p} F_{\alpha}(p, n-p) \tag{64.3}$$

Its lower limit is 0.

For each sample, calculate its sample statistic $T_j^2 (1 \le j \le p)$. If there are at least one sample (such as jth sample) to make $T_j^2 > UCL(1 \le j \le p)$, then the production process is out of control. Otherwise the process is thought in control.

64.2.2 Coordinate Data Monitoring of Point and Plane

(1) Coordinate data monitoring of point

Suppose to monitor p points of a part, $X = [\mathrm{X}_1, \mathrm{X}_2, \ldots, \mathrm{X}_\mathrm{p}]'$, point $X_i = (x_i, y_i, z_i)$ $(i = 1, 2, \ldots, p)$.

$$X = \begin{pmatrix} (x_1, y_1, z_1) \\ (x_2, y_2, z_2) \\ \vdots \\ (x_p, y_p, z_p) \end{pmatrix}$$

When process keeps in control, mean vector $u = (\bar{x}, \bar{y}, \bar{z})$, covariance matrix S is

$$S = \begin{pmatrix} s_{xx} & s_{xy} & s_{xz} \\ s_{yx} & s_{yy} & s_{yz} \\ s_{zx} & s_{zy} & s_{zz} \end{pmatrix}$$

Use statistic T^2 about the mean vector to monitor these points. It's similar to line monitoring but more simple.

(2) Coordinate data monitoring of plane

In space, three points which are not in a line can constitute a plane. So a plane can be composed by at least three points. Monitoring of plane can be regarded as monitoring of N points (N3).

Monitor P planes of a part, $S = [S_1, S_2, \ldots, S_p]'$. Plane S_i express the following:

$$S_i = (x_{1i}, y_{1i}, z_{1i}, x_{2i}, y_{2i}, z_{2i}, \ldots, x_{Ni}, y_{Ni}, z_{Ni}),\ N \ge 3, i = 1, 2, \ldots, p$$

In control state, its mean vector $u = (x_1, y_1, z_1, x_2, y_2, z_2, \ldots, x_N, y_N, z_N)$, covariance matrix

$$S = \begin{pmatrix} s_{x_1x_1} & s_{x_1y_1} & \cdots & s_{x_1z_N} \\ \vdots & \vdots & \vdots & \vdots \\ s_{z_Nx_1} & s_{z_Ny_1} & \cdots & s_{z_Nz_N} \end{pmatrix}_{N \times N}$$

Here, there should be at least three points X_i, X_j and X_k and $(X_i - X_j) \ne m(X_j - X_k)$ $(m \ne 0)$.

64.3 Performance Analysis

Reduce three-dimension spatial to two-dimension plane, namely monitor two quality variance x_1 and x_2. For traditional SPC, process is in control when the sample data mean $\overline{x_1}$ and $\overline{x_2}$ both in their control limit. In the actual production, judging the process is control or not through monitoring changes of the two quality characteristic parameter dependently is against basic principle of control chart. When process is in control, $\overline{x_1}$ and $\overline{x_2}$ beyond its 3σ control limit, namely the first type error probabilities are both 0.0027. If $\overline{x_1}$ and $\overline{x_2}$ are both in control, its probability is. Its first type error probability is. The joint probability of two variables are both out of control is, which is much smaller than 0.0027. Therefore, using two independent mean is against normal control chart's basic principle when monitor $\overline{x_1}$ and $\overline{x_2}$ at the same time. The first type error probability and probability comes from the right analysis according to data of control state are not equal to demands of control charts basic principle.

To analyze multivariate control problems with statistic χ^2, the joint control area of $\overline{x_1}$ and $\overline{x_2}$ is an ellipse, shown in Fig. 64.1. The process is in control if $\chi^2_{\alpha,2}$ calculated by a pair mean $(\overline{x_1}, \overline{x_2})$ is internal of ellipse, otherwise it is out of control.

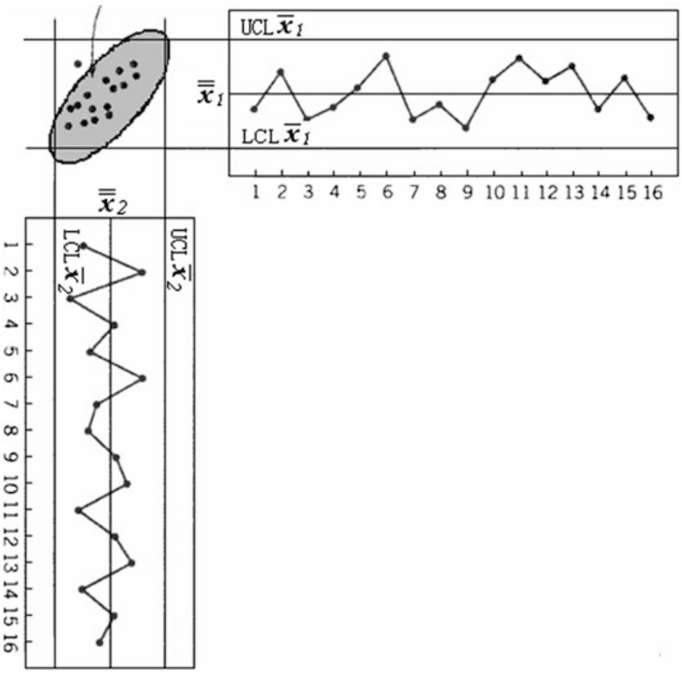

Fig. 64.1 Control ellipse of two uncorrelated independent variable

In Fig. 64.1, a sample point outside the oval shows that some identified abnormal reasons exist. If considered $\overline{x_1}$ and $\overline{x_2}$ control charts partly, the sample point is in their control limits. But customers will soon find abnormal quality in products.

From the study upon, χ^2 control chart display process control much more accurate. We assume $\sum$ is known in χ^2 control chart, actually $\sum$ is unknown and can't be arbitrary assumption. Usually we use limited sample data to estimate $\sum$ and T^2 control chart instead of χ^2 control chart.

64.4 Numerical Example

In this section, we used raw data given by literature (Wu 2006) and (Kang and Albin 2000) to calculate.

Here, we set up the first type error probability $\alpha = 0.005$. Calculate UCL of T^2 control chart by function (64.3) we get UCL = 13.61. Figure 64.2 shows T^2 control chart of the process. It can be easily seen that 18th and 19th points beyond UCL, for the performance of the signal out of control.

From Fig. 64.3, 19th point is out of control but 18th is in control. This phenomenon shows traditional SPC control chart already cannot satisfy production process quality monitoring requirements.

Usually average running length (ARL) is used as index in evaluating the superiority of quality monitoring method. The mistake alarm probability of control is designed as low as possible when process is in control, that is, the value of ARL bigger is better. When process is out of control, the alarm of control chart should be popped up as soon as possible, that is, the value of the alarm smaller may be more beautiful.

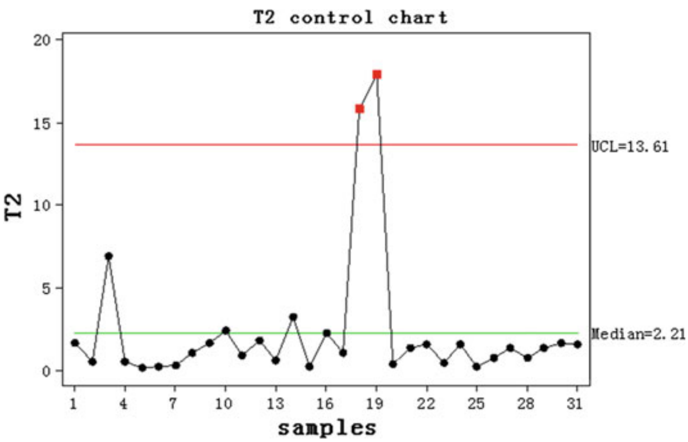

Fig. 64.2 T^2 control chart

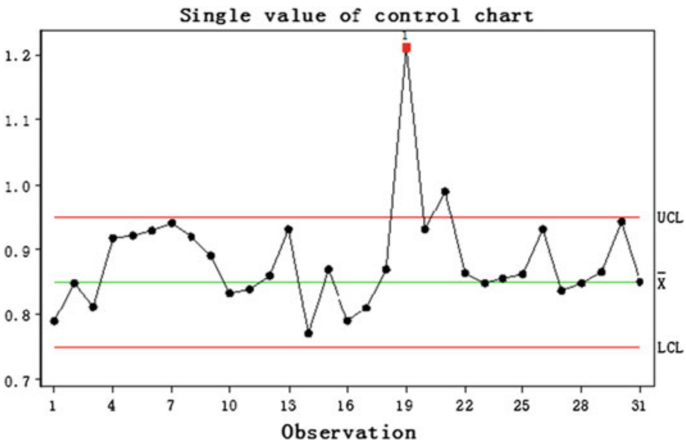

Fig. 64.3 Traditional SPC control chart

Compare the efficiency of vector dimension monitoring and traditional scalar dimension monitoring with MATLAB simulation platform. Following is the numerical example of line vector monitoring.

In order to monitor the shift process, we use shift parameter to measure the degree of control chart shift (Gan 1991).

In order to monitor the migration process, by adopting Lowry, put forward to measure deviation from the parameters of control chart the excursion of the degree.

Assume the mean vector in control $\mu_0 = [0, 0, 0, 0, 0, 0]$, covariance matrix in control

$$\Sigma_0 = \begin{pmatrix} 1 & 0.7 & 0.9 & 0.3 & 0.2 & 0.3 \\ 0.7 & 1 & 0.8 & 0.1 & 0.4 & 0.2 \\ 0.9 & 0.8 & 1 & 0.1 & 0.2 & 0.1 \\ 0.3 & 0.1 & 0.1 & 1 & 0.2 & 0.1 \\ 0.2 & 0.4 & 0.2 & 0.2 & 1 & 0.1 \\ 0.3 & 0.2 & 0.1 & 0.1 & 0.1 & 1 \end{pmatrix}$$

where, μ and $\sum$ are mean vector and covariance matrix for observation data. In the simulation, assuming that mean the shifts and the covariance keep the same in process. The shift matrix set as:

$$shift = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0.1 & 0.1 & 0.1 & 0.1 & 0.1 & 0.1 \\ 0.15 & 0.15 & 0.15 & 0.15 & 0.15 & 0.15 \\ 0.2 & 0.2 & 0.2 & 0.2 & 0.2 & 0.2 \\ 0.25 & 0.25 & 0.25 & 0.25 & 0.25 & 0.25 \\ 1 & 1 & 1 & 1 & 1 & 1 \end{pmatrix}$$

Table 64.1 ARL of T^2 and Shewhart control chart

Control chart	Appearance	
Shift	T^2	Shewhart
0	212.1588	370.4
0.2	126.6887	237.76
0.25	83.564	211.2
0.35	84.6028	178.76
0.5	35.0345	155.22
1	4.8369	43.895
1.5	1.3214	14.968
2	1.0206	6.303
3	–	2

The mean vector moves along the shift matrix.

Hypothesis virtual alarm rate, the simulation results are as follows:

When the process keeps in control, the value of *ARL* is bigger, the process is more stable. In this condition, Shewhart control chart is better than T^2 from the first line in the Table 64.1. People hope *ARL* is smaller may be more beautiful when the process shift exists, so T^2 control chart is more sensitive and timely than traditional control chart.

64.5 Conclusion

This paper mainly studied the coordinate data monitoring method with MSPC. The monitoring of three basic geometrical elements, point, line and plane, are discussed. The results show the MSPC not only reflect the process control more accurately than traditional SPC, but also can timely monitor the abnormal process through coordinate data monitoring. Also coordinate data monitoring is helpful in dimensional control of rigid parts in manufacturing process since traditional SPC only focus on the scalar data and ignore structure information of three dimensional coordinate data.

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Chapter 65
A New Method to Estimate Software Size

Xue-li Ren and Yu-biao Dai

Abstract Cost estimation is a key content of software project management, its accurate depends on size estimation. FPA is a method used widely to estimate size, but it has many problems in itself. A novel method is proposed to solve these problems which estimate sizes using FPA based on UML for objects having no analogy in historical data and using paired comparisons for objects having analogy in historical data. FPA based on UML is used to solve complexity of FPA; Paired comparisons are used to solve problems which do not reflect the trends of today's software engineer. The processes of the novel method are elaborated on and illuminated using an example.

Keywords Case-based reasoning · FPA · Paired comparison · UML

65.1 Introduction

In recent years, the increasing scale and complexity of software are developed by software engineers in the whole fields, which make software system projects most expensive component. Accurate software estimation is a crucial part of any software project so that the project can be priced adequately and resources allocated appropriately (Pressman 2011). Accurate cost estimation depends on accurate size measurement.

Many methods are used in software size estimation. There are lines of code called LOC (Pressman 2011), CK measurement (Whitmire 1995), LK measurement, 3-D function point, function point analysis called FPA and so on. Counting

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for LOC is feasible when the program is completed. The counting is helpful for productivity and performance measurement and evaluation. However, for planning of software effort, duration and cost purpose, one cannot wait until the software is finished. The methods that CK measurement and LK measurement only adapt to the software that are developed using object oriented development. The method called 3-D function point is adapted to software productivity analysis. The method called FPA that is a standard for size estimation has been used widely.

65.2 FPA

65.2.1 FPA

FPA estimate size based on the five function types which are External Input (EI), External Output (EO), External Query (EQ), Internal Interface File (ILF), and External Interface File (EIF) (IFPUG 2004). Each of these five function types is individually assessed for complexity and given a Function Point value which varies from 3 (for simple external inputs) to 15 (for complex internal files). The Function Point values are based the complexity of the feature being counted. The low, average and high complexity level of ILF and EIF are based on the number of Record Element Type (RET) and Data Element Type (DET). A Record Element Type (RET) is a subgroup of the data element (record) of an ILF or ELF. A data element type is a unique non-repeated data field.

The complexity level of EI and EO and EQ are based on the number of File Type Referenced (FTR) and Data Element Type (DET). A File Type Referenced (FTR) is an ILF or EIF.

The Unadjusted Function Points is sum of all the occurrences which is computed by multiplying each function count (N) with a Function Point weighting (W), and then the UFP is attained by adding up all the values.

The Function Point values obtained can be used directly for estimating the software project schedule or software costs. But in some cases, it may need further adjustments with the software development environment factors.

In order to find adjusted FP, UFP is multiplied by value adjusted factor (VAF) which is calculated form 14 technical complexity factors (TCF)

65.2.2 Problems in FPA

The method called FPA that is a standard for size estimation has been used widely, but it has many disadvantages in itself.

(1) Rules to count function point are described using sample natural language, so measurement results are impacted by subjectivity of works easily.

(2) It is more complex, higher staffs and longer time are required, and meantime completeness and accuracy for requirements are also required.
(3) Sizing is measured manually, so cost is higher.
(4) The weight values of unadjusted FP are said to reflect the size of the software. They have never been updated since being introduced in 1979 and are applied universally. In contrast, software development methods have evolved steadily since 1979, but today's software differs drastically from what it was over two decades ago.
(5) The weight values of unadjusted FP were determined by Albrecht by "debate and trial" (Lavazza et al. 2013), based on his experience and knowledge. Albrecht contributed significantly to the theory of FP; nevertheless, with no actual follow-up projects to justify his values, the question remains as to whether the weight values were defined subjectively without convincing support or whether they reflect objective data.
(6) The weight values of unadjusted FP were decided based on the study of data processing systems at IBM. The assignment of weight values was restricted to only one organization and to only a limited amount of software types; however, this set of weight values is applied universally and is not limited to one organization or one type of software.

65.3 A Novel Method to Estimate Size

As are analyzed, problems 1, 2 and 3 make the method not fully reflect software complexity and unwieldy, UML is a common method to analyze and design (Fowler 2003; Larman 2004), so FPA based on UML is proposed to solve them (Lavazza et al. 2013; Raju 2010; Fu and Liu 2010). Problems 4, 5 and 6 do not reflect the trends of today's software. Paired comparisons is studied by Lederer and Prasad (1992) and the result shows that using historical data and documented comparisons produce better estimates, so paired comparisons is used to solve them. In an attempt to address these problems, this paper proposes a novel method which have advantages of FPA and paired comparisons to estimate size whose process of estimation is shown in Fig. 65.1:

65.3.1 FPA Based on UML

It increases workload not only less that the rules to measure size are analyzed form results of requirements, but also accuracy is higher (Lin 2008). UML is a common method to analyze and design, so size is measured based on that.

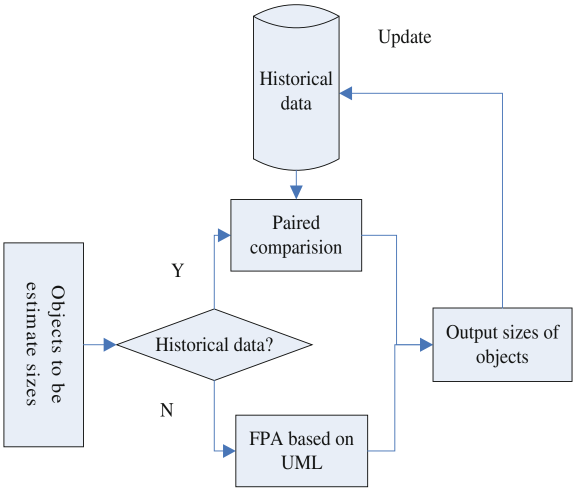

Fig. 65.1 The method to estimate size

(1) Calculate FPs of data types
Numbers of DET are counted from class diagrams, but not any class is as a file. A class in class diagrams is as a file based on following rules:

Rule 1: If there are not association, aggregation, composition and generalization relations between a class and other classes, then the class is counted a file.
Rule 2: If there are two classes A and B connected by a composition relation as shown in Fig. 65.1, and class B is not connected to class A by any other class, then they must be mapped to one logic file for the composition relation with 2 RETs. In addition, one DET for each attribute for both classes must be counted.
Rule 3: If there are classes that are connected through a generalization relation and there are unique attribute among their child classes, count one logic file with two RETs (one for the parent class and one for the child classes). If not, count every logic file with 1 RET.
Rule 4: Association Class
If business requirements indicate that the association class belongs to only one of the logic files, the RET would be counted only with that logic file. If not, the association class must be mapped to one independent logic file with one RET.
FPs is counted based numbers of DET and RET.

(2) Calculate FPs of transaction types
FPs of transaction types are counted from messages between actors and boundary class or between boundary class and data files in sequence diagrams based on following rules:

Rule 1: the message which is sent from actor to boundary class is as an external input (EI).
Rule 2: the message which is sent from boundary class to actor is as an external output (EO).

Rule 3: the message which is sent from boundary class to data files is as an internal write.
Rule 4: the message which is sent from data files to boundary class is as an internal read.
Rule 5: the operations which are realized by components are ignored.
After transaction types are defined, numbers of DET and RET are calculated using sequence diagrams, and FPs are calculated finally.

(3) Calculating unadjusted function point (UFP):
UFP = FPs of data types + FPs of transaction types.
(4) Calculate value adjustment factor (VAF)
The value adjustment factor (VAF) is based on 14 general system characteristics (GSCs) that rate the general functionality of the application being counted. They are data communications, distributed data processing, performance, heavily used configuration, transaction rate, on-Line data entry, end-user efficiency, on-Line update, complex processing, reusability, installation ease, operational ease, multiple sites and facilitate change.
Each characteristic has associated descriptions to determine the degrees of influence. The degrees of influence range on a scale of zero to five, from no influence to strong influence. Once all the 14 GSC's have been answered, VAF is calculated using the following formula.

$$VAF = 0.65 + 0.01 * (F1 + F2 + \cdots + F14) \qquad (65.1)$$

In that, Fi is the degrees of influence to system

(5) Calculate FPs of system
FPs of system is calculated using the following formula.

$$FPs = UAF * VAF \qquad (65.2)$$

65.3.2 The Paired Comparisons

The method called paired comparisons requires the existence of at least one reference object whose size is known (Rosenberger et al. 2002; Brown and Peterson 2009), for example, from a previous development project. The choice of a reference object is very important that straightly influence on result estimated accurate, so the referent objects are chosen by analogy based on case-based reasoning (Burkhard and Richter 2000), the processes of paired comparisons are shown in Fig. 65.2:

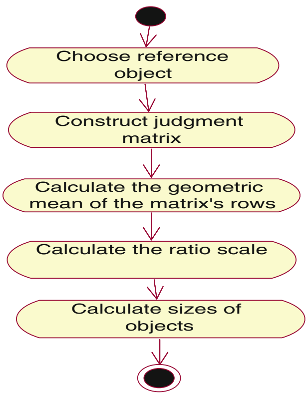

Fig. 65.2 The processes of paired comparisons

(1) Choose reference object

The reference projects are chosen by analogy form historical data which is calculate using case-based reasoning. If many objects are found in analogy, then, the object whose value in similarity is largest is chosen; if no object is found, then the method isn't adopted, the method FPA based on UML is used to measure size.

(2) Construct judgment matrix

The judgment matrix is a square matrix whose size is n, where n is the number of objects being compared; and each element captures the relative size of object i with respect to object j. The elements of the matrix are defined as

$$\mathrm{A} = [a_{ij}] \quad a_{ij} = \frac{s_i}{s_j} \tag{65.3}$$

in that, $\frac{s_i}{s_j}$ is value that the object i to estimate with respect to object j; $a_{ji} = \frac{1}{a_{ij}}$, s_j is the reference object; if $a_{ij} > 1$, then size estimated object is larger than the reference object; if $a_{ij} < 1$, then size estimated object is smaller than the reference object; if $a_{ij} = 1$, then size estimated object is equal to the reference object;

(3) Calculate the geometric mean of the matrix's rows

The geometric means of the matrix's rows are calculated using the following formula (65.4):

$$g_i = \sqrt[n]{\prod_{j=1}^{n} a_{ij}} \tag{65.4}$$

(4) Calculate the ratio scale

The ratio scales are calculated using the following formula (65.5):

$$r_i = \frac{g_i}{\sum_{l=1}^{n} g_l} \tag{65.5}$$

(5) Calculate sizes of object

The absolute sizes of object are calculated using the following formula (65.6)

$$size_i = \frac{r_i}{r_{reference}} * size_{reference} \tag{65.6}$$

65.4 Example

As the method to estimate object sizes using FPA based on UML is sample, no example is given in the paper. The only example to estimate size is shown using paired comparisons. Firstly, a reference project is chosen by case-based reasoning form historical data; then a judgment matrix is created:

$$\begin{bmatrix} 1 & 0.5 & 6 & 4 \\ 2 & 1 & 1.5 & 3 \\ 0.16 & 0.7 & 1 & 2 \\ 0.25 & 0.33 & 0.5 & 1 \end{bmatrix}$$

Applying formula 65.4, we calculate the geometric means of rows $\begin{bmatrix} 1.86 \\ 1.73 \\ 0.69 \\ 0.45 \end{bmatrix}$; and normalize $\begin{bmatrix} 0.39 \\ 0.37 \\ 0.15 \\ 0.10 \end{bmatrix}$ using formula (65.5).

Assuming that object A is the reference point and its size is 210 FPs, we can calculate the absolute size of the other objects using formula (65.6): $\begin{bmatrix} \frac{0.39}{0.39} * 210 \\ \frac{0.37}{0.39} * 210 \\ \frac{0.15}{0.39} * 210 \\ \frac{0.10}{0.39} * 210 \end{bmatrix}$. The size of second object is 199 FPs, the third object is 81 FPs and the forth is 54 FPs. The results of size estimation are close to the true values.

65.5 Conclusion

FPA that is a standard for sizing estimation has been used widely to estimate size of software development, but many problems in it make it inadaptable to today software engineer. A new method to estimate sizes are proposed which improve the problems in FPA. The method estimates size using FPA based on UML for objects having no analogy in historical data and using paired comparisons for objects having analogy historical data. The particular processes of method are given in the paper and case-based reasoning is used to find analogical objects. The method which is used in size measurement has good effect.

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Chapter 66
A New Model-Free Control Chart for Monitoring Univariate Autocorrelated Processes

Xu-tao Zhang, Zhen He, Chi Zhang and Yun Wang

Abstract A new model-free control chart called Chi square control chart is proposed. Firstly, the autocorrelation function is used to measure the stability of the process. Secondly, appropriate delay time is selected to reduce the data correlation and make data approximately satisfy IID assumption. Then, the Chi square statistics for monitoring are designed through data matching based on phase space reconstruction. Guidelines for designing the control chart are presented by an example of AR (1) process. Result shows that, the control chart cannot only avoid the false alarm when the process is under control, but also can timely detect the variation of the process out of control. This method doesn't need model fitting, and the efficiency in data usage is high for its autoregressive character, which makes it suitable for quality monitoring online.

Keywords Autocorrelated processes · Quality monitoring · Model-free approach · Chi square control chart · Phase space reconstruction

66.1 Introduction

Control charts are widely used in modern quality management, not only for monitoring the production processes, but also for detecting the variation of the processes. Conventional control charts such as Shewhart, CUSUM and EWMA

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chart are based on the assumptions that the data generated by the process when it is in control are normally and independently distributed. However, with improvement of measurement and data collection technology, processes can be sampled at higher rates, which can often lead to data autocorrelation. In addition, data autocorrelation also exists prevalently in the chemical, pharmaceutical and other continuous production processes. For autocorrelated processes, conventional control charts do not work well if the quality characteristic exhibits even low levels of correlation over time. Specifically, these control charts will give misleading results in the form of too many false alarms if the data are positively correlated. In recent years, control charts for monitoring autocorrelated processes have received great attention of the scholar in quality control area (Psarakis and Papaleonida 2007).

The approaches for monitoring autocorrelated processes generally can be divided into three categories. The first approaches use control limits adjustment. Wardell et al. (1994) point out the fact that the control limits of SPC charts would be affected by the autocorrelation in the process data. For positive autocorrelated processes, the control limits are much tighter than desired, which cause a substantial increase in the average false alarm rate. For negative autocorrelated processes, the control limits are much wider than desired, which causes a decrease in the ability of detecting changes on the process. So the control limits should be adjusted to account for the autocorrelation and the true process variance should be estimated (Montgomery and Mastrangelo 1991). However, due to the change of control limits width will often cause misunderstandings to the quality level, and the control limits set lacks uniformly accepted standards, the application of limits adjustment are restricted. The second approaches are model-based approaches, which involving fitting a time series model to the process data and monitoring the model residuals. If the model is exact, then the model residuals are independent. Consequently, standard SPC control charts can be applied to the residuals. However, many people seem to agree that the residuals charts do not have the same properties as the charts for the original observations. Moreover, if the model fitting is not very well, the residuals are not IID. Jing (2002) pointed out that the residual analysis is insensitive to the mean when the process is positively autocorrelated. To the same conclusion came Zhang, Lu and Reynolds and others (Min and Zhen 2007; Lu and Reynolds 1999; Alwan and Roberts 1988). The third approaches are model-free approaches. The basic idea is breaking up or diluting the autocorrelation in process data (Krieger et al. 1992). Krieger (Runger and Willemain 1996) thought that the data correlation is due to high sampling frequency. It is advisable to sampling from the process data stream less frequently to meet the independence. Runger and Willemain (Shumway and Stoffer 2005) proposed a batch means control chart. The chart breaks successive groups of sequential observations into batches, and the autocorrelation between data is diluted by batch means. Model-free methods makes conventional control chart available for correlated process. However, it lack of efficiency in data usage. The inefficient use of available data can lead to a decrease of the performance of control charting since with limited data it may take much longer to detect a real process shift than with all the data.

In view of the drawbacks in existing methods, a new model-free control chart which does not rely on model fitting and has high efficiency in data usage is proposed. The Chi square statistics for monitoring are designed through data matching based on phase space reconstruction. Thus, it can be called Chi square control chart. Guidelines for designing the control chart are presented by an example of AR(1) process.

66.2 Basic Theories

66.2.1 Time Series Model of Autocorrelated Process

Time series model is commonly used to describe the dynamic regularity of autocorrelated process, which is usually called autoregressive integrated moving average ARMA (p, q) model (Kantz and Schreiber 1997)

$$\phi(B)X_t = \theta(B)\varepsilon_t \tag{66.1}$$

where $\phi(B) = 1 - \phi_1 B - \cdots \phi_p B^p$, $\theta(B) = 1 - \theta_1 B - \cdots \theta_q B^q$, ε_t is Gauss white noise, that is $\varepsilon_t \sim N(0, \varepsilon_t^2)$.

The simples and most widely used time series model is called a first-order autoregressive AR(1) model. Let $\{x_1, x_2, \ldots x_t \ldots\}$ is the observed data sequences, the differential equation for AR(1) model is

$$x_t = \xi + \phi x_{t-1} + \varepsilon_t \tag{66.2}$$

where ξ is unknown constants, ϕ is autocorrelation coefficient, and ε_t is normally and independently distributed with mean zero and standard deviation σ_1. When $\phi > 0$, the process is positive correlated; when $\phi < 0$, the process is negative correlated; the larger $|\phi|$ is, the higher correlation in process exits, consequently, $x_{t\text{-}1}$ affect x_t bigger.

66.2.2 Stationary Analysis of Time Series

In the process of the production of quality control, the basic assumption is that the process is in steady state and in statistical control. Therefore, before designing control chart for the time series, stationary analysis should be done first. There are lots of methods for stationary analysis of time series, and the most commonly used methods include autocorrelation function (ACF) method, partial autocorrelation function (PACF) method and so on (Shumway and Stoffer 2005). In this paper, we use autocorrelation function (ACF) method.

The autocorrelation function measures the linear dependence between two points on the same series observed at different times. The autocorrelation over a series of time oriented observations is measured by the function (Montgomery 2009)

$$\rho_k = \frac{Cov(x_t, x_{t-k})}{V(x_t)} \quad k = 0, 1, \ldots \tag{66.3}$$

where $Cov(x_t, x_{t-k})$ is the covariance of observations that are k time periods apart, and we have assumed that the observations have constant variance given by $V(x_t)$. We usually estimate the values of ρ_k with the sample autocorrelation function

$$\hat{\rho}_k = \frac{\sum_{t=1}^{n-k} (x_t - \overline{x})(x_{t-k} - \overline{x})}{\sum_{t=1}^{n} (x_t - \overline{x})^2} \quad k = 0, 1, \ldots, K \tag{66.4}$$

Statistical analysis software such as Minitab can completed the calculation of ρ_k and plotting directly. We can analyze the stationary of the time series according to the convergence ρ_k. If the ρ_k series all equal to zeros approximately, it indicates that the time series are random series; If the ρ_k series have rapid convergence, then the time series are stationary, otherwise not stationary.

66.2.3 Basic Theories of Phase Space Reconstruction

The concept of phase space reconstruction first appeared in the field of statistics, and has been widely used in dynamical systems time series analysis. The basic idea is that, the output components of a dynamics system have mutual connection and influence with each other, the evolution of a component may be decided by the evolution of other components. Through studying one or more components of a system, embedding them into a multidimensional state space by time delays, the Pseudo-phase space of the system can be established (Zhang et al. 2005).

Set $[x_1, x_2, \ldots, x_N]$ is the output of a component from an n-dimensional system. Through choosing the embedding dimension m and the delay time p, we can establish a time window$[m, p]$, which can make m elements with p intervals appear simultaneously, then we can get an m-dimensional state vector

$$X_i = [x_i, x_{i+p}, \ldots, x_{i+(m-1)p}] \quad i = 1, 2, \ldots, N - m + p \tag{66.5}$$

The space composed of $N - m + p$ Vectors X_i is called Pseudo-state phase space, which has one to one mapping relationship with the original system. The Takens Theorem (Takens 1981) has proved that if the selections of delay time and embedding dimension are appropriate, the reconstructed phase space is equivalent to the original dynamical system topologically.

66.3 Design Steps

For the observations of an autocorrelated quality process with time series $\{x_1, x_2, \ldots x_t \ldots\}$, we can establish a model-free control chart (called Chi square control chart) as followed steps:

Step 1: Analyzing the stability of the autocorrelated quality process

According to the principles of stationary analysis of time series described earlier, we can calculate and plot the ρ_k series through Minitab software. The process can be seen stable if the ρ_k series have rapid convergence. Otherwise, EPC methods should be considered to adjust the process.

Step 2: Selecting the delay time p to reduce the data correlation

We know that less frequent sampling can break up the autocorrelation in process data. The data approximately satisfy IID assumption if the autocorrelation parameter ρ_k is likely zero. We can choose the lag steps k when $|\rho_k|$first achieves the minimum (Wang and Qin 2004) as the delay times p. From the chart of ρ_k constructed by Minitab, we can easily find the suitable delay times.

Step 3: Selecting the embedding dimension m

Takens theorem implies that, if the attractor of the dynamical system is d-dimensional, the reconstructed phase space has a embedding of the original dynamical system when $m \geq 2d + 1$. That is only a sufficient condition. Ding et al. (1993) had proved that we can choose the embedding dimension m which is integer smallest larger than the original dimension for the noise-free, infinite data. Specially, for first-order linear time series, the dimension is 1, when they are mapped to a 2-dimensional plane, the amount of information between each other is equal. Therefore, we can choose m as 2 in this situation.

Step 4: Constructing the Chi square statistics for monitoring

For the stable autocorrelated quality process with observations $\{x_1, x_2, \ldots x_t \ldots\}$, which have mean μ, standard deviation σ_2. Choose the delay times as p, and the embedding dimension as m. Because the correlations between data are reduced by delay times, $x_{t-(m-1)p}, x_{t-(m-2)p}, \ldots, x_{t-p}, x_t$ approximately satisfy IID assumption. Then the statistics for monitoring is constructed

$$\chi_m^2 = \frac{(x_{t-(m-1)p} - \mu)^2 + (x_{t-(m-2)p} - \mu)^2 + \cdots + (x_t - \mu)^2}{\sigma_2^2} \tag{66.6}$$

The statistics follows the Chi square distribution with m freedom. Note that the variable subscript in this formula is arranged according to the way forward retrospective of the current observations, which is different from formula (66.5). The statistics designed this way have the autoregressive character, which is convenient for the habit of recording a point when a new output observation is obtained in contours online quality monitoring.

$(x_{t-(m-1)p}-\mu)^2+(x_{t-(m-2)p}-\mu)^2+\cdots+(x_p-\mu)^2$ represents for the Euclidean distance from the m-dimensional state vector to the center, according to the theory of phase space reconstruction mentioned before.

Specially, for the first-order autoregressive AR(1) model expressed by formula (66.2). When we choose the dimension m as 2, formula (66.6) can be simplified

$$\chi_2^2=\frac{(x_t-\mu)^2+(x_{t-p}-\mu)^2}{\sigma_2^2} \tag{66.7}$$

where $\mu=\xi/(1-\phi), \sigma_2=\sigma_1/(1-\phi^2)^{1/2}$.

Step 5: Setting the control limit for the control chart

For the stable autocorrelated quality process with observations $\{x_1, x_2, \ldots x_t \ldots\}$, we can establish the Chi square control charts by recording the point in sequence through formula (66.2). Set the error probability of the control charts is α, then the control limit for the control chart is the 1-α quantile of the Chi square distribution with m freedoms

$$\text{UCL}=\chi^2_{\alpha,m} \tag{66.8}$$

66.4 Example Analysis

Without loss of generality, for the AR (1) autocorrelated process expressed by formula (66.2), set $\xi=0$, $\phi=0.8$, $\varepsilon_t \sim N(0,1)$. Figure 66.1 shows the time sequence diagram of the process, the front 300 data are in steady-state sequence, assuming that the process has 1σ mean shift after $t=301$.

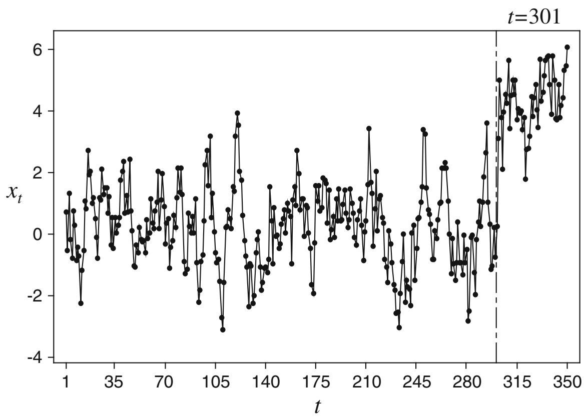


Fig. 66.1 AR(1) time series diagram

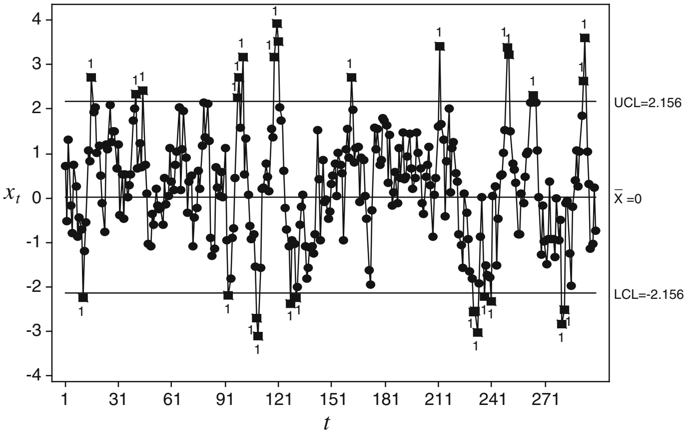


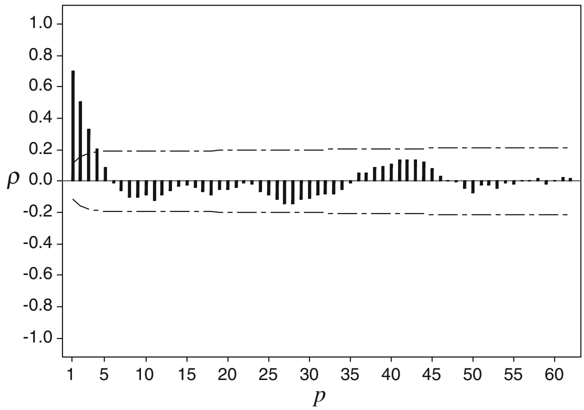
Fig. 66.2 Invalid Shewhart control chart

For the front 300 steady-state data, if we use the conventional Shewhart control chart for monitoring, due to the autocorrelations in process data, there are many out-of control points in the chart making lots of false warnings, indicating the control chart works invalidly, as presented in Fig. 66.2.

Figure 66.3 shows the sample autocorrelation function parameter ρ_k of the front 300 steady-state data by Minitab. From the figure we can see that ρ_k series have rapid convergence, indicating the time series are stationary. $|\rho_k|$ first achieves the minimum at 6 steps lag, thus we choose the delay times $p = 6$.

Choose $m = 2$, $p = 6$, we design the Chi square statistics for monitoring by formula (66.7). Because the probability of a point out of the limits in Shewart control chart is 0.27 %, hence the limit of the Chi square control chart is settled as $\text{UCL} = \chi^2_{0.0027,2} = 11.83$ in order to compare the performance. As Fig. 66.4 shows, the control chart work well for the stable process, with all the points under the control limit.

Fig. 66.3 Sample autocorrelation function



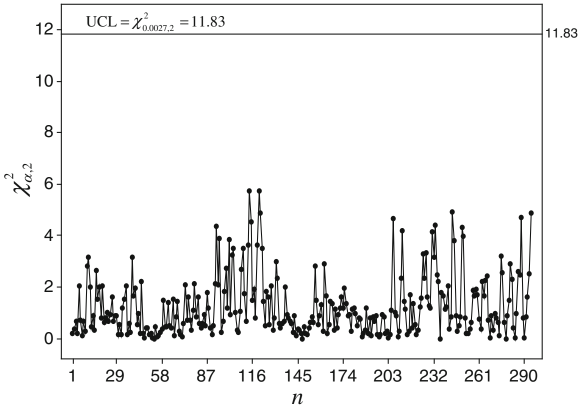


Fig. 66.4 Chi square control chart when the process is under control

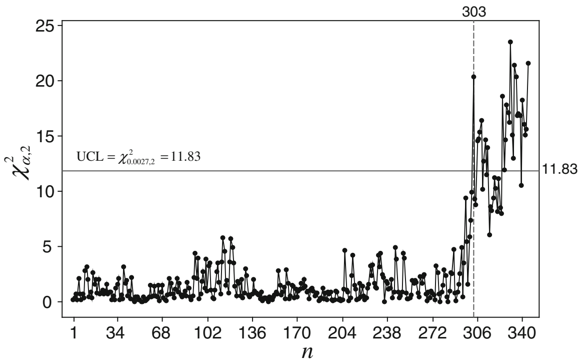


Fig. 66.5 Chi square control chart when the process is out of control

In order to test the performance of Chi square control chart for monitoring the mean shift in the process, we set the process has 1σ mean shift after $t = 301$, corresponding Chi square control chart is shown in Fig. 66.5. The Chi square statistics are out of control at $n = 303$. Note that the delay time $n = 303$. The variation of the process is detected $t = n{+}p = 309$, check and control measures should be taken in consideration.

We can conclude from Figs. 66.4 and 66.5 that the model-free control chart proposed can not only avoid the false alarm when the process is under control, but also can timely detect the variation of the process out of control.

66.5 Discussion

Conventional control charts work not well for monitoring the autocorrelated processes. In this situation, the points out of the limits do not necessarily represent for an out-of-control process, and the points in the limits do not necessarily represent for a under control process. The reason roots in the autocorrelation in process data and not meeting the IID assumptions. For the autocorrelated process, because the current observation is affected by the front observations, consequently, the information reflecting the characteristics of the current process from current observation is too small. Therefore, it is advisable to determine whether the current process is under control by considering numbers of points which are independent with the current point in judgment. In this paper, we use the autocorrelation function to measure the stability of the autocorrelated process. Then we make data approximately satisfy IID assumption by appropriate delay time selecting. Finally, we design a Chi square statistics for monitoring through data matching based on phase space reconstruction. This method doesn't need model fitting, and the efficiency in data usage is high for its autoregressive character, which makes it suitable for quality monitoring online. The ARL characteristics of the chart need further study. The methods use multivariate vectors to monitoring the unvaried processes, which would be unsuitable for the multivariate autocorrelated processes.

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Chapter 67
Application of Quality Management Maturity Assessment System in Small and Medium-Sized Enterprises

Zhou-li Zhang and Fa-shan Dai

Abstract According to the problem that Chinese small and medium-sized enterprise quality management level is low and based on Crosby's quality management maturity model, questionnaire is designed according to the actual situation of enterprise and sequence relations act and fuzzy comprehensive evaluation method is applied in studying the model of quantification in the process of application of small and medium-sized enterprises. Research shows that enterprise can determine which stage it is according to this method. What is more, it can also understand the influence factors of its quality level and improve it later.

Keywords Fuzzy comprehensive evaluation · Quality management · Quality management maturity · Small and medium-sized enterprise

67.1 Introduction

China's economy has been obtaining a fast development after entering the WTO, so do the small and medium-sized enterprises (SMEs). The SMEs are a force to be reckoned to support China's rapid economic growth, low prices of whose products is one of the factors that attracted consumers. However, with the global trade competition and consumers' focus on the quality of products, the managers come to realize that the low price is not the key factor in consumers' purchasing of goods. Meanwhile, the consumers' concentration is on prices of the products corresponding

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with their qualities and services (Lee and Zhou 2000). Therefore, it is definitely important and urgent for SMEs to improve the level of quality management.

Presently, the SMEs have managed to do well in the quality management in the developed countries and regions, and the applications of the maturity of quality management in those areas had been studied by many scholars, for example, the U.S. Malcolm Baldrige National Quality Award Evaluation System, which is designed to evaluate manufacturing enterprises, SMEs and service industries, combines the theory of quality management maturity. Unfortunately, in mainland of China, the research of quality management maturity is relatively limited. In addition, the relationship of quality management maturity and SMEs and its applications has not yet appeared.

Compared with the developed countries and regions, the SMEs 'level of quality management in China has a very large gap. The backward of quality management results in the poor quality of products manufactured by a part of SMEs and the quality control beyond managing, which lead to series of problems and hindering the further development of SMEs (Liang 2003). Although lots of SMEs actively seek for and adopt methods to improve the quality of products, the conditions are not improved. Therefore, studying on the SMEs' level of quality management, establishing the evaluation system, and identifying the key factors for the enterprises entering into the next maturity stage, not only can guide the SMEs to perform the quality management, but also is very important for the departments to amend the quality management standards and rules (Su Q et al. 2010).

67.2 Establishing the Evaluation System

Crosby considered that estimating the actual status of the quality management from the important elements of quality management, measuring the efficiency and potential of effects on quality management and increasing the competitiveness of the enterprises as quality management maturity. In addition, he divided the quality management maturity into five stages that is uncertainty, awakening, enlightenment, wisdom and certainty, respectively. The quality management maturity grid is as shown in Table 67.1 (Crosby 1979).

Table 67.1 The quality management maturity grid

Stage 5	Certainty
Stage 4	Wisdom
Stage 3	Enlightenment
Stage 2	Awakening
Stage 1	Uncertainty

Table 67.2 UI assigned values

u_i	Definition
1	When two factors are equally important
1.2	The previous factor is more important than the latter one
1.4	The previous factor is obviously more important than the latter one
1.6	The previous factor is much more important than the latter one
1.8	The previous factor is extremely important
1.1, 1.3, 1.5, 1.7	Between the middle of the factors mentioned above

67.2.1 Assign Weights

(1) Assign the primary index weights

In this paper, the primary index weights are assigned with the Ordered Relations Act combined with analyzed questionnaire data (Xiang et al. 2009). The Ordered Relations Act can refer to corresponding articles and the rational assignment is shown in Table 67.2.

After finishing the questionnaire, the index weights are determined according to the process of establishing the relation index sets, assigning the rational values u_i, determining the each index weight. Then the obtained weight vectors $W = [\omega_1, \omega_2, \cdots, \omega_n]$.

(2) Assign the secondary index weights

The questions of evaluation questionnaire are set based on the secondary indices. And each secondary index consisted of five stages, and the contents of the questionnaire are set according to the 5 stages. The score is one, two, three, four and five, respectively, corresponding with criteria of rather poor, poor, good, very good, excellent.

Assuming that there are n pieces of questionnaire in total, the mean of each evaluation item is computed:

$$\overline{X}_i = \sum_{i=1}^{n} x_i \Big/ n \tag{67.1}$$

The weights are computed as Eq. (67.2):

$$\beta = \overline{X}_i \Big/ \sum_{j=1}^{n} \overline{x_j} \tag{67.2}$$

where $\overline{x_i}$ denotes the mean of the secondary in the same level, and β denotes the index weights.

67.2.2 Evaluate Steps

(1) Establishing the evaluation factor sets, which applied the fuzzy synthetic evaluation (Wang and Chai B 2011). The properties index sets as follows derived by the experts' evaluation:

$$Q = \{Q_A, Q_B, \ldots, Q_G\}$$

(2) Establishing the evaluation word sets:

$$\mathrm{N} = \{y_{1,}, y_{2,} \Lambda, y_5\} = \{ratherpoor, \ poor, \ good, \ verygood, \ excellent\}$$

The experts judge the levels corresponding with the evaluation words, and then the each level's probability will be statistically computed.

(3) Performing fuzzy synthetic evaluation in each level
The fuzzy synthetic evaluation of the secondary indices is as follow:

$$F_i = \beta_i * Q_i (i = A, B, \ldots, Z)$$

The fuzzy synthetic evaluation of the primary indices is as follow:

$$V = W * F$$

67.3 Practical Applications

67.3.1 Weights Assignment of the Quality Management Maturity

A manufacturing enterprise is planning to evaluate its quality management maturity, and has carried out a convey, which had invited 52 experts in the field of quality management to conduct the questionnaire, and 47 copies recovered are available.

(1) Processing the recovered questionnaire and applying the Ordered Relation Act, and then the seven primary indices weight vectors can be obtained as follows:

$$W = (\omega_1, \omega_2, \omega_3, \omega_4, \omega_5, \omega_6, \omega_7) = (0.14, 0.19, 0.28, 0.11, 0.07, 0.10, 0.11)$$

With Eqs. (67.1) and (67.2), the data processed is shown in Table 67.3.

(2) According to the data collected and processed, the factor fuzzy matrices of quality management maturity are as follows:

Table 67.3 The weights of the secondary indices

The primary indices	The secondary indices	$\overline{x_i}$	β
Leader A	Understanding and attitude to the condition of quality	4.236	0.256
	The sources demanded of the quality activities	4.112	0.249
	The participated level of improved the quality activities	4.336	0.262
	Summarize the conditions of quality	3.860	0.233
	Analyze the advantages and disadvantages	4.015	0.322
Strategies and planning B	Establish the plan and objectives of quality, make sure it can be carried out	4.121	0.331
	The situation of quality organization	4.321	0.347
Centered on the customers C	The level of understanding the customer and markets	3.852	0.306
	The mutually conditions of organizations and customer	4.216	0.335
	Customer satisfactions	4.527	0.359
Information management D	Collect data and analyze	4.001	0.502
	The controlling level of data and files	3.973	0.498
Resources management E	Training	4.301	0.352
	Employees satisfactions	3.783	0.309
	The conditions of QC can well play its roles	4.147	0.339
Process management E	Process of quality management system (QMS)	4.331	0.153
	The index of processing ability	3.924	0.139
	Supporting process	3.786	0.134
	Selecting the supplies and control process	3.824	0.135
	The processing results when quality problems occur	4.038	0.143
Process management E	The performing level of the improved measures related with the quality	4.251	0.150
	The preventive measures	4.100	0.145
	Quality cost (percentage of the sales amount)	3.862	0.192
Performance of quality management G	The disqualification rate or the services failure rate	4.327	0.215
	The rework rate of the goods or services	4.024	0.200
	Defective rate of goods	4.125	0.205
	The level of organization σ	3.825	0.190

$$Q_A = \begin{bmatrix} 0.00 & 0.10 & 0.45 & 0.30 & 0.15 \\ 0.00 & 0.20 & 0.50 & 0.18 & 0.12 \\ 0.02 & 0.16 & 0.46 & 0.20 & 0.16 \\ 0.01 & 0.17 & 0.45 & 0.21 & 0.16 \end{bmatrix}$$

$$Q_B = \begin{bmatrix} 0.00 & 0.18 & 0.42 & 0.33 & 0.07 \\ 0.01 & 0.25 & 0.55 & 0.16 & 0.03 \\ 0.02 & 0.28 & 0.47 & 0.19 & 0.04 \end{bmatrix}$$

$$Q_C = \begin{bmatrix} 0.00 & 0.14 & 0.36 & 0.44 & 0.06 \\ 0.01 & 0.07 & 0.39 & 0.47 & 0.06 \\ 0.03 & 0.09 & 0.62 & 0.16 & 0.10 \end{bmatrix}$$

$$Q_D = \begin{bmatrix} 0.00 & 0.27 & 0.58 & 0.14 & 0.01 \\ 0.00 & 0.15 & 0.52 & 0.30 & 0.03 \end{bmatrix}$$

$$Q_E = \begin{bmatrix} 0.02 & 0.13 & 0.46 & 0.37 & 0.02 \\ 0.00 & 0.03 & 0.56 & 0.24 & 0.17 \\ 0.01 & 0.12 & 0.47 & 0.38 & 0.02 \end{bmatrix}$$

$$Q_F = \begin{bmatrix} 0.01 & 0.25 & 0.39 & 0.32 & 0.03 \\ 0.01 & 0.07 & 0.39 & 0.47 & 0.06 \\ 0.03 & 0.09 & 0.52 & 0.25 & 0.11 \\ 0.00 & 0.03 & 0.56 & 0.24 & 0.17 \\ 0.01 & 0.16 & 0.46 & 0.22 & 0.15 \\ 0.00 & 0.16 & 0.50 & 0.30 & 0.04 \\ 0.02 & 0.12 & 0.47 & 0.36 & 0.03 \end{bmatrix}$$

$$Q_G = \begin{bmatrix} 0.01 & 0.19 & 0.40 & 0.35 & 0.05 \\ 0.00 & 0.22 & 0.50 & 0.15 & 0.13 \\ 0.00 & 0.04 & 0.56 & 0.23 & 0.17 \\ 0.01 & 0.12 & 0.47 & 0.38 & 0.02 \\ 0.02 & 0.25 & 0.53 & 0.16 & 0.04 \end{bmatrix}$$

(3) According to the secondary index weights in Table 67.2, the corresponding primary index probability vectors are as follows:

$$F_A = \beta_A * Q_A = [0.0076, 0.1569, 0.4651, 0.2230, 0.1475]$$

In the same way, what can be obtained as follows:

$$F_B = [0.0102, 0.2379, 0.4804, 0.2252, 0.0464]$$

$$F_c = [0.0141, 0.0986, 0.4634, 0.3495, 0.0744]$$

$$F_D = [0, 0.2102, 0.5501, 0.2197, 0.0200]$$

$$F_E = [0.0104, 0.0957, 0.4943, 0.3332, 0.0663]$$

$$F_F = [0.0113, 0.1284, 0.4681, 0.3088, 0.0824]$$

$$F_G = [0.0078, 0.1639, 0.4934, 0.2538, 0.0832]$$

What can be seen from the computed results is that the primary indices (index) are all in the good stage, namely the third stage. Besides, a number of experts think that the enterprise is in a good stage. So the enterprise should take actions to improve the factors which affect the evaluation of the quality management maturity and try to enter the next stage.

67.3.2 The Development of the Quality Management Maturity

From above, this enterprise' primary indices of quality management maturity is

$$W = (\omega_1, \omega_2, \omega_3, \omega_4, \omega_5, \omega_6, \omega_7) = (0.14, 0.19, 0.28, 0.11, 0.07, 0.10, 0.11),$$

then each stage probability of this enterprise' quality management maturity is obtained as follows:

$$W = (\omega_1, \omega_2, \omega_3, \omega_4, \omega_5, \omega_6, \omega_7) = (0.14, 0.19, 0.28, 0.11, 0.07, 0.10, 0.11)$$

so what can be seen from the result is that the stage of this enterprise is

$$V = \max\{0.0099, 0.1535, 0.2810, 0.0743\} = 0.4814,$$

which indicates the stage is the enlightenment stage. In this stage, it means that the staff of enterprise has realized the importance of quality management and the managers can be involved into the improvement of the quality management. At the same time, the enterprise is able to confirm and solve the quality problems.

67.4 Conclusions

Given to the practical development of China's SMEs, an evaluation system of quality management maturity established is applied to the management of SMEs, and the following conclusions are reached:

(1) Through the evaluation of 5 stages of quality management maturity, SMEs can apply the evaluation system to quantify itself established in this paper according to its actual situations, and then by comparing the evaluated result with the 5 stages of quality management maturity, it can clarity the development stage of its quality management maturity.
(2) The SMEs can figure out each factor's stage, which affects the quality management maturity in the process of evaluating its quality management maturity. And then the enterprises can pay different attention to the factors according to their effect on the enterprises' entering the next stage. Thus the SMEs' quality management activities can performs normally by coordinating the development of various factors.
(3) The evaluation system of quality management maturity can also be applied to large-scale manufacturing enterprises.

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Chapter 68
Application Research on SPC in Automobile Parts Enterprise

Xiao-min Xu

Abstract After China's accession to the WTO, the product quality has become a major factor of competitiveness. In recent years, customer demands for the products increase day by day because of the change of manufacturing, the fierce market competition, the improvement of quality control techniques and information technology. In this paper, the SPC method is used for analyzing the quality of products of one company in Shanghai, we can find the reason on affecting the quality of products by analyzing and monitoring the quality characteristics value of parts.

Keywords Control charts · Quality management · Statistical process control (SPC) · Variance analysis

68.1 Background and Signification

The quality is the eternal subject in our life. It relates to raising the level of people's lives, involving millions families. After the Reform and Opening up, China's commodities gradually enter the international market and experience fierce market competition test, the importance of quality has become increasingly evident. The Statistical Process Control (SPC) method is accepted by many enterprises in this situation. Today, it has become one of the most important tools to control the stability of output, widely used in various manufacturing enterprises

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worldwide. With the continuous improvement of the growing production requirements and production processes, it is particularly important to use the SPC to prevent and manage the product quality. In this paper, we use the parts of a Shanghai auto parts manufacturing company as a research object, we apply SPC methods to analyze the sampling data of the parts in the production process, and then provide basis for decision making for enterprises to control the stability of product quality.

68.2 Literature Summary

Statistical process control (SPC) is a process control tools, with the methods of mathematical statistics. It is the use of the statistical regularities of the fluctuations in the process analysis and control. Shao-min Wu and Hui-qing Li (2000) mentioned that in any case, according to a certain standard (including design standards, material standards, process standards, work standards, etc.), there is always a difference between the manufacture of a large number of similar products, even the same one operating in the same device, using the same raw materials, processing likewise process the same number of parts, and measuring instruments of the same kind of measurement, the results are not identical, a phenomenon known as the fluctuations in the quality. The most prominent feature of Statistical Process Control is the timely warning of abnormal fluctuations. Jing Sun, Hua Wang, Yi-ming Gong and Jian-xin You etc. (Zhang and Sun 2002; Wang 2009; Gong et al. 2009; Yang et al. 2010; You et al. 2008) mentioned that the quality difference is the inherent nature of the manufacturing process, fluctuations in the quality of objective necessity. The task of the production process quality control, quality characteristics should be the value of control within the specified ranges, making the process under control, and stable production of qualified products. The fluctuation range is too large, and the product quality cannot be guaranteed; if the blind narrow fluctuations control range, it will increase the difficulty and expense of quality control. Qian et al. (2004) pointed out that the statistical process control is the use of control charts and other statistical techniques to analyze the process and its output, through appropriate measures to achieve and maintain process stability, in order to achieve improvement and ensure product quality. Li et al. (2009) mentioned that statistical process control is a kind of process control method, it will be used to process the principle of mathematical statistics and monitoring, in-depth observations of the variation of the process, and to help analyze the causes, and in order to take measures to stabilize and improve the process capability process. Yang and Zhang (2011) said, SPC focuses on the process monitoring and fault detection, can share the calculation process quality parameters and analyze the quality of the process of target meet degree. But when the quality characteristics do not meet the normal distribution and independence requirement, the traditional control charts, process capability analysis method met obstacles. Cui et al. (2007) and Han (2009) said control charts in international industry are mature and widely used, and proved effective tool for increasing productivity, a successful control chart can significantly reduce the abandonment of products and heavy industry or rework the opportunity. Ji et al. (2010) believed the traditional quality inspection stage after the quality guarantee will lead to inspection lag and cause certain economic losses. Choice for process of production line of the statistical theory and method, to determine the key variable is the most important. Liao et al. (2008) mentioned that control charts about the production process of sampling monitor although very economy, but there are also risks. One is the virtual sound the alarm of mistakes, also called the first kind of mistakes, and the second is omitted to send warning of mistakes, also called the second type of error. To control the figure is through the selective examination to monitor the quality of the products, the two errors are inevitable. Zhou et al. (2009) mentioned that for quality management is concerned, we must take quality data as the basis to make a judgment on the quality of product specific. So we need to collect data, sorting data, and to use the corresponding analysis of data and some methods. Therefore, quality management includes a large number of statistical jobs. Junfang Chen (2007) thought the statistics and control method of quality characteristics is the application of the sampling theory of mathematical statistics to measure quality characteristics of product samples randomly drawn from the inspection of products, to infer all conditions of product quality characteristics and possible future trend of quality characteristics through the sample data processing and analysis, and so as to prevent and control the quality of the products.

68.3 Relevant Theoretical Research

68.3.1 Statistical Process Control

SPC is real-time monitoring and evaluating all phases of production by means of statistical analysis technology in order to distinguish the random and abnormal fluctuations of products quality in the production process and put forward early warning to abnormal trends of the production process. Management personnel can take measures to eliminate the abnormal and ensure products and services to meet the requirements and improve product quality. We can do the job through control charts.

68.3.2 Statistical Process Control

The variance analysis is to make clear and study data of various factors on the influence degree and properties through the analysis of data. The method is to regard observations of K as a whole and divide the squares and freedom of the total variance of observation data into different variations of freedom and squares of the source, and get the population variance estimation of different variations of source. The variance analysis is essentially a quantitative analysis about variation reasons of observations.

68.4 Empirical Study

In this article, a Shanghai auto parts production dashboard beam assisted left bracket is studied to analyze and control processes that affect the product.

68.4.1 Analysis of the Main Reasons for Failure of the Product Quality

The following table (Table 68.1) is the sample of one month for the products of the enterprise. We can obtain from Table 68.1 that substandard part aperture is the main factors to affect the quality of the parts.

68.4.2 Control the Parts Pore Size

(1) $\bar{x} - R$ Control chart (Table 68.2)

According to the formula (68.1) and (68.2):

Table 68.1 Within one month of the instrument panel beams auxiliary left bracket failure defect data

Defect	Defect number	Cumulative defects	Frequency (%)	Cumulative frequency (%)
Substandard parts aperture	346	346	44.8	44.8
Surface roughness of failure	109	455	14.1	58.9
Scratches, bumps	98	553	12.7	71.6
Rust	77	630	10.0	81.6
Hole shift	65	695	8.4	90.0
Material failure	53	748	6.9	96.9
Other matters	24	772	3.1	100.0
Total	772			

Table 68.2 Parts aperture of the auxiliary left bracket of instrument panel beams

Number	$\bar{x}-R$ Control chart data						
	X_1	X_2	X_3	X_4	X_5	Average	Range
1	13.30	13.27	13.30	13.20	13.30	13.27	0.10
2	13.20	13.00	13.20	13.10	13.20	13.14	0.20
3	13.00	13.10	13.10	13.20	13.10	13.10	0.20
4	13.40	13.30	13.20	13.10	13.10	13.22	0.30
5	13.20	13.10	13.10	13.20	13.20	13.16	0.10
6	13.10	13.20	13.10	13.30	13.00	13.14	0.30
7	13.30	13.30	13.10	13.10	13.30	13.22	0.20
8	13.10	13.10	13.30	12.90	13.00	13.08	0.40
9	13.10	13.20	13.20	13.20	13.20	13.18	0.10
10	13.40	13.20	13.20	13.10	13.40	13.26	0.30
11	12.90	13.10	13.10	13.20	13.10	13.08	0.30
12	13.00	13.10	13.10	13.20	13.10	13.10	0.20
13	13.30	13.20	13.10	13.10	13.20	13.18	0.20
14	13.20	13.30	13.20	13.20	13.00	13.18	0.30
15	13.10	13.20	13.00	13.10	13.10	13.10	0.20
16	13.20	13.20	13.20	13.20	13.30	13.22	0.10
17	13.00	13.20	13.40	13.20	13.40	13.24	0.40
18	13.20	13.10	13.10	13.10	13.10	13.12	0.10
19	13.10	13.10	13.30	13.20	13.30	13.20	0.20
20	13.35	12.98	13.00	13.00	13.20	13.11	0.37
21	12.90	13.00	13.20	13.20	12.90	13.04	0.30
22	12.80	12.86	13.00	13.30	13.20	13.03	0.50
23	13.10	13.11	12.87	13.20	12.90	13.04	0.33
24	13.20	13.00	13.10	13.13	13.20	13.13	0.20
25	13.20	13.15	13.14	13.22	13.00	13.14	0.22
Average						13.15	0.24

Unit: mm

$$\overline{\overline{X}} = \frac{1}{25}\sum_{i=1}^{25}\overline{x}i \tag{68.1}$$

$$\bar{R} = \frac{1}{25}\sum_{i=1}^{25}Ri \tag{68.2}$$

So $\bar{\bar{X}} = 13.20$, $\bar{R} = 0.22$.

So

$$UCL_R = D_4\overline{R} \tag{68.3}$$

$$CL_R = \overline{R} \tag{68.4}$$

$$LCL_R = D_3\overline{R} \tag{68.5}$$

$$UCL_{\overline{X}} = \overline{\overline{X}} + A_2\overline{R} \tag{68.6}$$

$$CL_{\overline{X}} = \overline{\overline{X}} \tag{68.7}$$

$$LCL_{\overline{X}} = \overline{\overline{X}} - A_2\overline{R} \tag{68.8}$$

By the sample size n = 5, so A2 = 0.577, D3 = 0, D4 = 2.114. We can get the following values:

$$UCL_R = 0.47,\ CL_R = 0.22,\ LCL_R = 0;$$

$$UCL_{\overline{X}} = 13.33,\ CL_{\overline{X}} = 13.20,\ LCL_{\overline{X}} = 13.08.$$

$\overline{x} - R$ Control chart is shown in Fig. 68.1. According to control chart sub-different principle, there are abnormalities in the production process, X-bar figure alarms. Then the process is out of control.

Therefore, we need identify the reason for the deletion of influencing factors and re-sample to calculate the mean and range values.

(2) Find the main factors

We know the factors affecting process quality are diverse, but summed up in five aspects to identify the reasons that the equipment (Machine), workmanship (Method), material (Material), the operator (Man) from these five aspects and environmental aspects (environment) to identify the reasons leading to fluctuations in the quality. The results are shown in Table 68.3.

Therefore the "human factors" is the main reason leading to substandard parts aperture, namely the carelessness of the workshop staff, faulty operation, or in

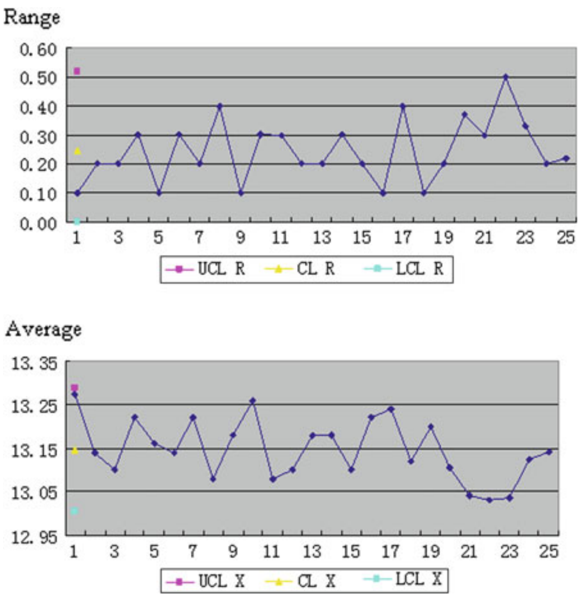

Fig. 68.1 Average range control chart

Table 68.3 Factor analysis of the affect parts aperture

Defect	Defect number	Cumulative defects	Frequency (%)	Cumulative frequency (%)
Human factors	212	212	61.3	61.3
Surface equipment wear and tear	61	273	17.6	78.9
Tool wear	43	316	12.4	91.3
Poor machining accuracy	19	335	5.5	96.8
Other matters	11	346	3.2	100.0
Total	346			

violation of the procedures operating to affect the quality. In order to solve this situation, the company strengthened the quality of publicity and education and required employees to memorize the respective responsibilities of quality and organization quality system examination so as to improve the quality of a company-wide awareness. At the same time, there was not only rational division of labor on the tasks of the staff, also increased the punishment of the quality of the accident. The shop inspectors increased the part random inspection efforts. Special inspection teams enhanced inspection on site and implement double economic sanctions to the onlookers and the workshop managers.

(3) $\bar{x} - R$ Control chart again

We collect data (Table 68.4) to draw $\bar{x} - R$ control chart again (Fig. 68.2). According to the Judging Stability Criteria, the diagram ideas in the control chart are in a controlled state.

68.4.3 Process Capability Analysis

It is known that tolerances of the requirements of the technical standard parts of the enterprise dashboard beam assisted left bracket aperture are $\phi\ 13.1^{+0.3}_{-0.2}$ mm.

$$\bar{x} = 13.10,\ \bar{R} = 0.15$$

So tolerance center,

$$T_M = \frac{T_U + T_L}{2} = \frac{13.4 + 12.9}{2} = 13.15 \tag{68.9}$$

Because $\bar{x} = 13.10 < T_M = 13.15$

$$\varepsilon = \left|T_M - \overline{X}\right| = |13.15 - 13.10| = 0.05 \tag{68.10}$$

$$T = T_U - T_L = 0.3 + 0.2 = 0.5$$

Table 68.4 Parts aperture of the auxiliary left bracket of instrument panel beams

Number	$\bar{x} - R$ Control chart data						
	X_1	X_2	X_3	X_4	X_5	Average	Range
1	13.00	13.20	13.20	13.10	13.20	13.14	0.20
2	13.00	13.10	13.10	13.10	13.00	13.06	0.10
3	12.95	13.10	13.06	13.10	13.10	13.06	0.15
4	13.10	13.21	13.20	13.19	13.10	13.16	0.11
5	13.10	13.06	13.10	13.05	12.95	13.03	0.15
6	13.10	13.19	13.10	13.18	13.00	13.11	0.19
7	13.17	13.00	13.00	13.11	13.19	13.07	0.19
8	13.10	13.15	13.20	13.15	13.14	13.15	0.10
9	13.10	13.10	13.10	13.10	13.00	13.08	0.10
10	13.10	13.10	13.09	13.10	13.24	13.13	0.25
11	13.01	13.26	13.00	13.03	13.00	13.06	0.26
12	13.00	13.10	13.00	13.00	13.10	13.04	0.10
13	13.10	13.10	13.00	13.10	13.20	13.10	0.20
14	13.10	13.14	13.10	13.14	13.00	13.10	0.14
15	13.10	13.20	13.00	13.10	13.10	13.10	0.20
16	13.20	13.25	13.10	13.09	13.20	13.17	0.16
17	13.00	13.10	12.97	13.14	13.10	13.06	0.17
18	13.20	13.10	13.10	13.10	13.10	13.12	0.10
19	13.10	13.10	13.10	13.10	13.20	13.12	0.10
20	13.20	13.10	13.00	13.10	13.10	13.10	0.20
21	13.10	13.10	13.20	13.30	13.20	13.18	0.20
22	13.10	13.20	13.00	13.10	13.10	13.10	0.20
23	13.00	13.00	13.10	13.00	13.10	13.04	0.10
24	13.20	13.10	13.10	13.00	13.10	13.10	0.20
25	13.14	13.20	13.20	13.10	13.10	13.15	0.10
Average						13.10	0.15

Unit: mm

Offset coefficient,

$$\kappa = \frac{\varepsilon}{\frac{T}{2}} = \frac{0.05}{\frac{0.5}{2}} = 0.2 \tag{68.11}$$

Process capability index,

$$C_{PK} = \frac{T - 2\varepsilon}{6\sigma} = \frac{T - 2\varepsilon}{6\hat{\sigma}} = \frac{0.5 - 2 \times 0.05}{6 \times \frac{0.15}{2.326}} \approx 1.03 \tag{68.12}$$

Among $\hat{\sigma} = \frac{\overline{R}}{d_2} = \frac{0.15}{2.326}$

The basic requirements of process quality are that the manufacturing quality of the product must comply with the quality of its design. The smaller the value of quality of the product characteristics fluctuates, the higher its process ability is. According to the criteria of the process capability index, the part of the process

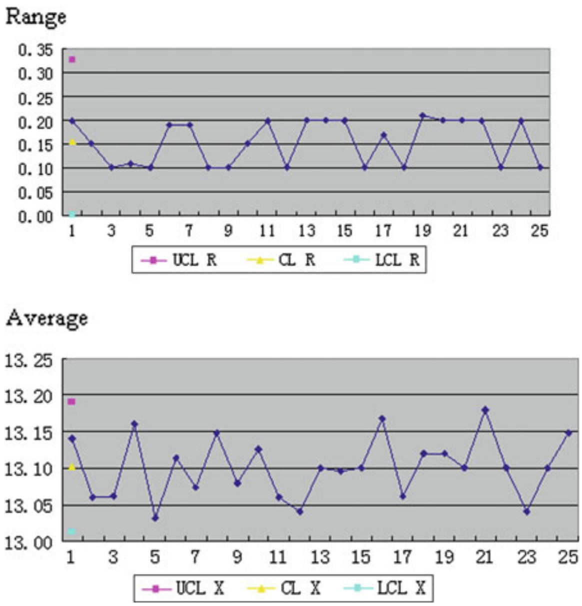

Fig. 68.2 Average-range control chart

capability index C_{pk} is 1.03 within the range $1.33 \geq C_{pk} > 1.00$, we can determine the process capability as normal. But due to the offset coefficient k is 0.2 in the range $0 < k < 0.25$, so we need to keep close observation of the mean time to improve control.

68.4.4 Analysis of the Application Effect Using Analysis of Variance

Using analysis of variance, we can analyze and make the judgment of the application to SPC effect.

Based on the above analysis, the main factors affecting the parts aperture are the result of carelessness or violation of regulations operating staff. Here it is seen as a single factor affecting the parts failed, denoted by the factor A. This factor has two levels, namely the state before improvements and the state after improvements; they are denoted as A_1 and A_2. The purpose is to verify whether the factors have the significant impact on test results, namely how the extent of the impact on the parts operated by the staff before and after. One data were respectively taken to improve the parts before and after the aperture data tested 10 times. Test results the following table. Table 68.5

Each experimental value minus 13.14. Then the transformed data was denoted by x_{ij} and obtained the equation form in Table 68.6.

Table 68.5 The data of results

Staff / Number of tests	A_1	A_2	
1	13.60	13.00	
2	13.40	13.20	
3	13.30	13.20	
4	12.90	13.10	
5	12.91	13.21	
6	13.20	12.95	
7	13.00	13.10	
8	13.20	13.06	
9	13.10	13.10	
10	13.20	13.10	
Average			13.14

Table 68.6 The equation form

Experimental values / Factor level / Number	A_1		A_2		$\sum_{j=1}^{2}$
	x_{i1}	x_{i1}^2	x_{i2}	x_{i2}^2	
1	0.46	0.2116	−0.14	0.0196	
2	0.26	0.0676	0.06	0,.0036	
3	0.16	0.0256	0.06	0.0036	
4	−0.24	0.0576	−0.04	0.0016	
5	−0.23	0.0529	0.07	0.0049	
6	0.06	0.0036	−0.19	0.0361	
7	−0.14	0.0196	−0.04	0.0016	
8	0.06	0.0036	−0.08	0.0064	
9	−0.04	0.0016	−0.04	0.0016	
10	0.06	0.0036	−0.04	0.0016	
$\sum_{i=1}^{10} x_{ij}^2$		0.45		0.08	0.53
$\sum_{i=1}^{10} x_{ij}$	0.41		−0.38		0.03
$(\sum_{i=1}^{10} x_{ij})^2$	0.17		0.14		0.31

$\alpha = 0.05$

H_0: The factors before and after improvement had no significant effect on the test results.

H_1: The factors before and after improvement had a significant effect on the test results.

Table 68.7 Analysis of variance table

Sum of squares of error	Degrees of freedom	Mean square error	F value	F_a value
SA = 0.08	m−1= 2−1 = 1	0.08/1= 0.08	F = 0.08/0.02 = 4	$F_{0.05}(1,18) = 4.41$
SE = 0.45	n−m= 20−2 = 18	0.45/18= 0.02		

So, between-group sum of squares:

$$S_A = \frac{1}{4}\sum_{j=1}^{2}\left(\sum_{i=1}^{10} x_{ij}\right)^2 - \frac{1}{12}\left(\sum_{j=1}^{10}\sum_{i=1}^{10} x_{ij}\right)^2 \approx 0.08 \qquad (68.13)$$

Within-group sum of squares:

$$S_E = \sum_{j=2}^{2}\sum_{i=1}^{10} x_{ij}^2 - \frac{1}{4}\sum_{j=1}^{2}\left(\sum_{i=1}^{10} x_{ij}\right)^2 \approx 0.45 \qquad (68.14)$$

Analysis of variance is shown in Table 68.7. Table 68.7 shows that F < Fa and therefore we cannot reject H0, i.e., before and after improvement of the factors had no significant effect on the test results.

68.5 Conclusion

Therefore, the human staff carelessness and of order operation is a major cause parts failure. Through improved, the process is controlled and the normal process capability is normal. We have more stringent safeguards on the quality of the product inspection and quality control through a comprehensive analysis of the SPC and the analysis of variance.

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Chapter 69
Comparing the Statistical Properties of T^2 Control Chart with VSSI and MEWMA Chart

Jing Zhang, Jian Liu and Chao Zeng

Abstract T^2 chart and MEWMA chart are used to monitor a process when more than one quality variable is being observed. Recent studies have shown that T^2 chart with variable sampling size and sampling interval (VSSI) detects a small shift in the process mean vector faster than the traditional T^2 chart. This paper analyses T^2 control chart with VSSI (T^2-VSSI) and MEWMA chart, and finds which one is better in statistical properties. ATS (Average Time to Signal) for T^2 control chart with VSSI and ARL (Average Run Length) for MEWMA chart are calculated by an approach called morkov chain. Then different values of some parameters are studied to get the optimal sampling scheme which makes ATS or ARL minimum. And the values of ATS and ARL are compared to find out the better one.

Keywords Markov chain · MEWMA chart · Statistical properties · T^2-VSSI control chart

69.1 Introduction

Control charts are used to monitor processes to detect any change that may result in quality defects. In the application of quality control, more researches used to be done on the single random variable. Nowadays, more and more attention is paid on

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multivariate statistical quality control which is on account of more indicators than one that decide the quality level in the process of production. And these variables are usually correlated. In this case, multivariate control charts are introduced to detect the mean vector and the variance. Now, most work has concentrated on monitoring the process mean vector. The widely used multivariate control charts are the Hotelling's T^2 control chart, multivariate cumulative sums (MCUSUM), multivariate exponentially weighted moving-average control chart (MEWMA). In this paper, we decide not to include MCUSUM chart, which is because comparing many chart at the same time is difficult and MEWMA is easy to understand.

Among these, T^2 control chart is not sensitive to small changes in the process mean vector. To improve statistical properties of the charts, the procedures of variable sampling size (VSS), variable sampling interval (VSI) and variable sampling size and interval (VSSI) have been applied to various control charts (see Aparisi 1996; Reynolds 1996; Aparisi and Haro 2001; Alireza et al. 2011).

Because the Hotelling (1947) multivariate control-chart is based on the most recent observation, it is insensitive to small and moderate shifts in the mean vector. Lowry et al. (1992) extended the univariate EWMA statistic to multivariate case. The MEWMA control chart takes into account the present and past information of the progress. So it is sensitive to small and moderate shifts. Prabhu and Runger (1997) present a Markov Chain approach to determine the performance of MEWMA chart. Reynolds and Kim (2005) investigated the MEWMA chart based on sequential sampling and unequal sample size. MH Lee (Kim and Reynolds 2005) investigated MEWMA chart with variable sampling intervals.

In this paper, we introduce the approach of markov chain to calculate the ARL for MEWMA chart and ATS for T^2-VSSI. It is assumed that the joint distribution of quality characteristics concerned in the process is multivariate normal, but its mean vector and covariance matrix when the process is in-control are assumed known. The parameters of the control charts are studied to make sure that the sampling scheme is feasible. Then we compare the efficient of T^2-VSSI and MEWMA chart.

69.2 Review of T^2-VSSI and MEWMA Chart

69.2.1 T^2-VSSI

We make the usual assumption that process quality is characterized with p correlated variable, which are jointly distributed as p-variate normal with in-control mean vector $\boldsymbol{\mu_0} = (\boldsymbol{\mu_{01}}, \boldsymbol{\mu_{02}}, \ldots, \boldsymbol{\mu_{0p}})'$ and covariance matrix $\Sigma(p \times p)$. Let $\overline{X_i}$ be $(p \times 1)$ independently random vectors. Each represents a sample mean vectors of p quality characteristics of interest, observed over time. The Hotelling's multivariate control chart signals a change in the mean vector of p correlated quality characteristics as soon as

$$T_i^2 = n(\overline{\boldsymbol{X}}_i - \boldsymbol{\mu}_0)'\Sigma^{-1}(\overline{\boldsymbol{X}}_i - \boldsymbol{\mu}_0) > \boldsymbol{k}.$$

If $\boldsymbol{\mu_0}$ and $\boldsymbol{\Sigma}$ are known, k is a specified action limit given by the upper α percentage point of Chi-square distribution with p degrees of freedom, denoting $\chi^2{}_{p\alpha}$.

Traditional Hotelling's T^2 chart operates with a sampling scheme of fixed sampling rate (FRS), which implies that a sample of size n_0 is drawn every h_0 h, and the value of the T^2 statistic is plotted on a control chart with $k = \chi^2_{p\alpha}$ as the action limit. The T^2-VSSI chart is a modification of the traditional T^2 chart. Let $(n_1,\ a \times h_0)$ be a pair of minimum sample size and longest sampling interval, and $(n_2,\ b \times h_0)$ be a pair of maximum sample size and shortest sampling interval. These pairs are chosen such that $n_1 < n_0 < n_2$ and $0 < b < 1 < a$. The decision to switch between pairs $(n_1,\ a \times h_0)$ and $(n_2,\ b \times h_0)$ depends on the prior sample point on the control chart. That is,

$$(n(i), h(i)) = \begin{cases} (n_2, b \times t_0) & if \quad w < T_{i-1}^2 \leq k \\ (n_1, a \times t_0) & if \quad 0 \leq T_{i-1}^2 \leq w. \end{cases}$$

Here w is the warning limit. $[0,\ w]$ is called the relaxing region and the tightening region is given by $(w,\ k]$ and $(k,\ \infty)$ is the alarming region.

69.2.2 MEWMA Chart

Suppose that p quality characteristics or process variables are monitored simultaneously over time t. And let the independent sequence of $p \times 1$ multivariate normal vectors $\boldsymbol{X}_t$ denote the observations at time t, such that $\boldsymbol{X}_t \sim N_p(\boldsymbol{\mu_0}, \boldsymbol{\Sigma_0})$, where $\boldsymbol{\mu_0}$ is the mean vector when process is on-target and $\boldsymbol{\Sigma_0}$ is the known covariance matrix. Without loss of generality assume that the process mean is the zero vector when the process is in control. Then the MEWMA can be defined as

$$\boldsymbol{Y_k} = \boldsymbol{RX_k} + (\boldsymbol{1} - \boldsymbol{R})\boldsymbol{Y_{k-1}}$$

where $\boldsymbol{R}$ is a diagonal weight matrix with the diagonal elements $r(0 < r \leq 1)$, and $\boldsymbol{Y}_0 = 0$. MEWMA is a statistical method that gives less weight to older data. The MEWMA control chart signals if

$$\boldsymbol{T}^2 = \boldsymbol{Y}'\Sigma_{\boldsymbol{Y_k}}^{-1} > \boldsymbol{H}$$

where Σ_{Y_k} is the covariance matrix of MEWMA vectors and $H > 0$ is a predefined control limit which is chosen to achieve a specified in-control ARL. Then

$$\Sigma_{\boldsymbol{Y_k}} = \left\{ r\left[1 - (1 - r)^{2k}\right] \Big/ (2 - r) \right\} \Sigma_X$$

However, in this thesis the following asymptotic covariance matrix is used when r is not very small.

$$\Sigma_{Y_k} = \left(\frac{r}{2-r}\right)\Sigma_X$$

The performance of a MEWMA chart is only a function of $\boldsymbol{\mu}$ through the non-centrality parameter

$$\delta^2 = (\boldsymbol{\mu} - \boldsymbol{\mu}_0)'\Sigma_X^{-1}(\boldsymbol{\mu} - \boldsymbol{\mu}_0).$$

69.3 Computing of ATS for T²-VSSI and ARL for MEWMA Chart Using Markov Chain

The statistical properties are assessed by the reaction time to the changes that result in quality defects in the process. ATS is the average time from the process means shift until the chart produces a signal (Costa 1997). However, when the intervals between samples are fixed, the speed with which a control charts detects process means shifts can be measured by the average run length (ARL). So, we can compute ATS for T^2-VSSI and ARL for MEWMA chart.

69.3.1 ATS for T^2-VSSI

The average time to signal (ATS) represents the average time needed for the control chart to detect a situation outside of control form the beginning of the process. In this paper, we use Markov chain to compute the value of ATS.

Based on the status of the process, one of the following states is reached:

State 1: $T_i^2 \in [0, w]$;
State 2: $T_i^2 \in (w, k]$;
State 3: $T_i^2 \in (k, \infty)$;

Using the Markov chain concepts, state 3 is referred as absorbing state. So, the transition probability matrix is given by

$$P = \begin{pmatrix} \boldsymbol{P}_{11} & \boldsymbol{P}_{12} & \boldsymbol{P}_{13} \\ \boldsymbol{P}_{21} & \boldsymbol{P}_{22} & \boldsymbol{P}_{23} \\ \boldsymbol{P}_{31} & \boldsymbol{P}_{32} & \boldsymbol{P}_{33} \end{pmatrix}$$

where $\boldsymbol{P}_{ij}$ denotes the transition probabilities from the previous state i to current j. Thus,

$$\begin{aligned}
\boldsymbol{P}_{11} &= \Pr(0 \le T^2 < w) = F(w,p,\eta_1)\\
\boldsymbol{P}_{12} &= \Pr(w \le T^2 < k) = F(k,p,\eta_1) - F(w,p,\eta_1)\\
\boldsymbol{P}_{13} &= \Pr(T^2 \ge k) = 1 - F(k,p,\eta_1)\\
\boldsymbol{P}_{21} &= \Pr(0 \le T^2 < w) = F(w,p,\eta_2)\\
\boldsymbol{P}_{22} &= \Pr(w \le T^2 < k) = F(k,p,\eta_2) - F(w,p,\eta_2)\\
\boldsymbol{P}_{23} &= \Pr(T^2 \ge k) = 1 - F(k,p,\eta_2)\\
\boldsymbol{P}_{31} &= 0;\ \boldsymbol{P}_{32} = 0;\ \boldsymbol{P}_{33} = 1
\end{aligned}$$

Here the notation $\mathrm{F}(x,p,\eta)$ represents cumulative probability distribution function of a non-central Chi-square distribution with p-degree of freedom and non-centrality parameter η. $\eta_0 = 0, \eta_1 = n_1 d^2$, $\eta_2 = n_2 d^2$. Here $d = \sqrt{(\mu_1 - \mu_0)'\Sigma^{-1}(\mu_1 - \mu_0)}$ is Mahalanobis Distance. Hence

$$\boldsymbol{ATS} = \boldsymbol{B}'(\boldsymbol{I} - \boldsymbol{Q})^{-1}\boldsymbol{H}$$

where, $\boldsymbol{B}' = (p_1,\ p_2)$ is a vector of initial probabilities, with $p_1 + p_2 = 1$ and $p_1 = \Pr(T_i^2 < w / T_i^2 < k; d = 0)$ is the proportion of times that the process remains in state 1 before the T^2 chart signals an out-of-control situation. $\boldsymbol{I}$ is the identity matrix of order 2 and $\boldsymbol{Q}$ is the 2×2 matrix obtained from $\boldsymbol{P}$ on deleting the elements corresponding to the absorbing state. $\boldsymbol{H}' = (a \times h_0, b \times h_0)$ is the vector of sampling time intervals. The values of a and b are chose so as to obtain an average sampling interval of h_0. So,

$$a \times h_0 \times p_1 + b \times h_0 \times p_2 = h_0.$$

Similarly, the average sampling size n_0 is obtained by means of the expression:

$$n_1 \times p_1 + n_2 \times p_2 = n_0.$$

Linking to the relationship of p_1 and p_2, we can get the value of w and n_2:

$$w = F^{-1}\left[\left(\frac{n_2 - n_0}{n_2 - n_1}\right)\alpha,\ p\right]$$

$$n_2 = (n_0 - n_1 \times p_1)/p_2$$

where F^{-1} is the inverse of the cumulative distribution of a central Chi-square with p degree of freedom.

Thus, all the parameters are p, d, α, n_0, h_0, a, b, n_1, n_2, w and k. Also, k, w and n_2 are calculated by other parameters.

69.3.2 ARL for MEWMA Chart

In the on-target case which $\boldsymbol{\mu}_0$ equals the zero vector, because $\boldsymbol{X}_t$ has a spherical distribution, the probability of a transition from state i to state j, denoted by $\boldsymbol{P}\,(i, j)$, depends only on the radii of state i to state j.

$$\begin{aligned}\boldsymbol{P}(i,j) &= P(q_t \text{ in state } j\,|q_{t-1} \text{ in state } i)\\ &= P\{(j-0.5)g < \|r\boldsymbol{Y}_t + (1-r)\boldsymbol{Y}_{t-1}\| < (j+0.5)g|q_{t-1} = ig\}\\ &= P\{(j-0.5)g < \|r\boldsymbol{Y_t} + (1-r)ig\boldsymbol{U}\| < (j+0.5)g\}\\ &= P\left\{(j-0.5)^2 g^2\Big/r^2 < \chi^2(p,c) < (j+0.5)^2 g^2\Big/r^2\right\}\end{aligned}$$

which $\chi^2(p,c)$ denote a noncentral Chi-squared random variable with p degrees of freedom and noncentrality parameter c, and $c = [(1-r)ig/r]^2$. For $j = 0$, we have

$$p(i,0) = P\{\chi^2(p,c) < (0.5)^2(g)^2\Big/r^2\}$$

For off-target case, we assume that the process mean shifts from the zero vector to $\boldsymbol{\mu}$ and let $\delta = \|\boldsymbol{\mu}\|$. Because the MEWMA is a function of the off-target mean only through the non-centrality parameter, the run length can be determined by assuming that $\boldsymbol{\mu} = \delta\boldsymbol{e}$. $\boldsymbol{Y}_t$ can be partitioned into two components which denoted by $\boldsymbol{W}_{t1}$ and $\boldsymbol{W}_{t2}$. The transitional probability of $\boldsymbol{W}_{t1}$ from state i_x to state j_x denoted by $h(i_x,j_x)$ can be obtained as follows

$$\begin{aligned}h(i_x,j_x) &= P(\boldsymbol{Y}_{t1} \text{ in state } j_x|\boldsymbol{Y}_{t1-1} \text{ in state } i_x)\\ &= P[-UCL + (j_x-1)g < r\boldsymbol{Y}_{t1} + (1-r)\boldsymbol{Y}_{t1-1}\\ &\quad < -UCL + j_x g|\boldsymbol{Y}_{t1-1} = c_{i_x}]\\ &= P[(-UCL + (j_x-1)g - (1-r)c_{i_x}/r - \delta)\\ &\quad < \boldsymbol{Y}_{t1} - \delta < (-UCL + j_x g - (1-r)c_{i_x}/r - \delta)]\end{aligned}$$

$$\begin{aligned}\text{So, } h(i_x,j_x) &= \Phi(-UCL + j_x g - (1-r)c_{i_x}/r - \delta)\\ &\quad - \Phi(-UCL + (j_x-1)g - (1-r)c_{i_x}/r - \delta)\end{aligned}$$

And the transitional probability of $\boldsymbol{W}_{t2}$ from state i_y to state j_y denoted by $v(i_y,j_y)$ is that

$$v_{i_y j_y} = \begin{cases} P\left\{\left(\frac{(j_y-0.5)g}{r}\right)^2 < \chi^2_{(p-1,c)} < \left(\frac{(j_y+0.5)g}{r}\right)^2\right\} & j_y \neq 0\\ P\left\{\chi^2(p-1,c) < (0.5g)^2\Big/r^2\right\} & j_y = 0\end{cases}$$

Let $\boldsymbol{P}$ denotes the transitional matrix of the transient states of the bivariate chain. The dimensions of $\boldsymbol{P}$ depend on the number of transient states. $\boldsymbol{P}_{int}$ denotes the starting vector of the chain and $\boldsymbol{E}$ denotes a vector of 1 s of the appropriate dimension, then $ARL = \boldsymbol{P}_{ini}(\boldsymbol{I} - \boldsymbol{P})^{-1}\boldsymbol{E}$.

69.4 Comparison Between T^2-VSSI and Mewma Chart

In T^2-VSSI control chart, for a particular production process, the values of p, d α, n_0 and h_0 are determined for the control chart, and then k is calculated. If we fix the value of a, b and n_1, then we can calculate n_2 and w. So, the minimum value of ATS is the function of a, b and n_1.

Based on the researches of the previous scholars, we have found that the lower the value of b the lower the value of ATS. Besides, if b is too low, it is infeasible in the real use of this procedure. So according to Aparisi, we choose b to be 0.1. Control limit $k = \chi^2_{p\alpha}$ is determined by p and α, where p is the number of the variable and α is the type 1 error. Here, we always choose 0.005.

In this paper, $b = 0.1$; $\alpha = 0.005$; h_0 is a constant which has no effect on the results and p, d, n_0 are fixed. We set $a \in [1.01, 3]$, $n_1 \in [1, n_0 - 1]$, and calculate k, w and n_2. So, we find the minimum value of ATS by changing the combinations of the parameters a and n_1. Besides, we do some researches on how p, d, n_0 produce an effect on ATS.

In MEWMA chart, the r, h, d and p are parameters that determine the performance of MEWMA chart. The pair (r, h) obtained is to get the desired in-control ARL ($ARL0$) and it will produce the lowest out-control ARL ($ARL1$) for a given shift. In this paper, we will set the $ARL0$ to 200. For each delta, from 0 to 2, there will be a pair of (r, h) which gets the desired $ARL0$ and the lowest $ARL1$. The $ARL1$ will be smaller as the delta getting bigger.

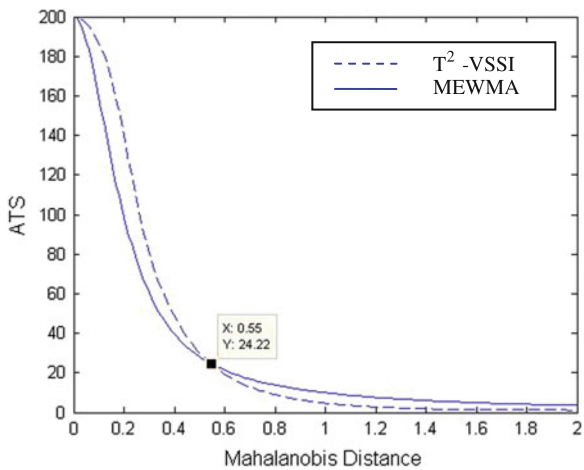


Fig. 69.1 ATS for T^2-VSSI and MEWMA ($p = 2$, $n_0 = 2$)

Fig. 69.2 ATS for T^2 with VSSI and MEWMA ($p = 2$, $n_0 = 3$)

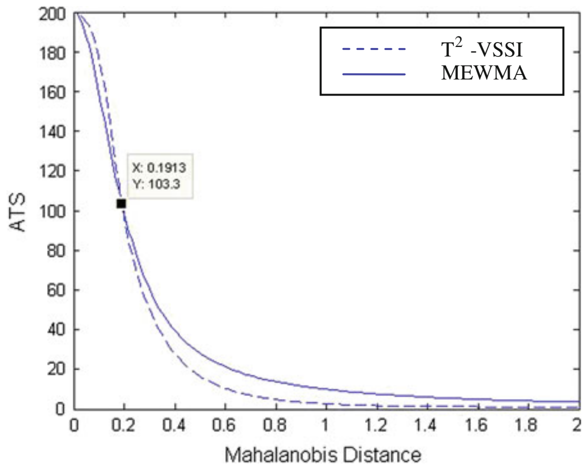


Fig. 69.3 ATS for T^2-VSSI and MEWMA ($p = 2$, $n_0 = 5$)

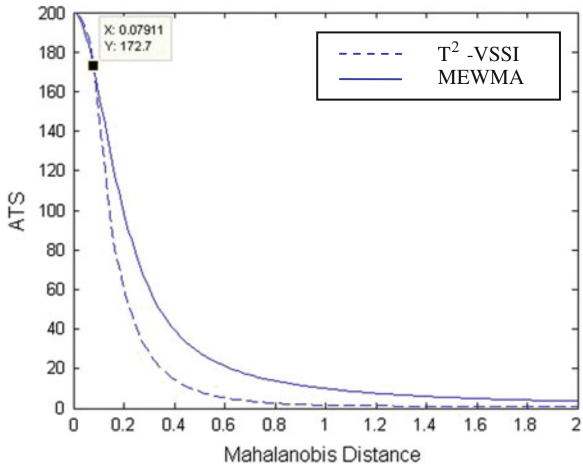


Fig. 69.4 ATS for T^2-VSSI and MEWMA ($p = 4$, $n_0 = 2$)

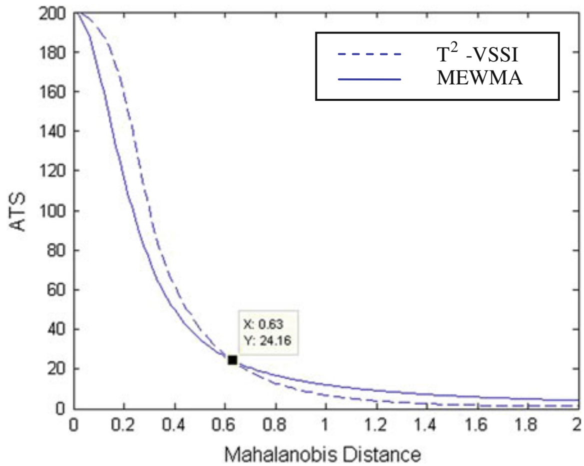


Fig. 69.5 ATS for T^2-VSSI and MEWMA ($p = 4$, $n_0 = 3$)

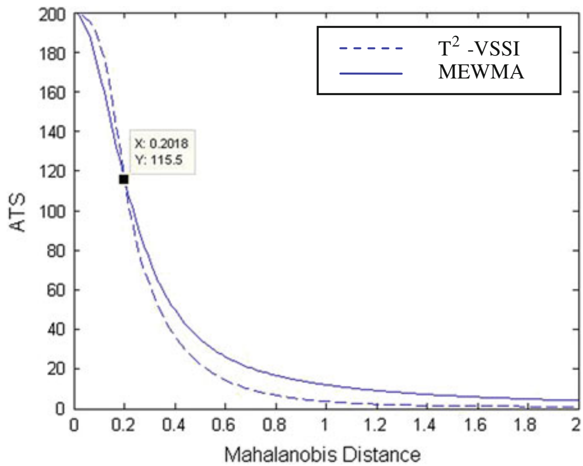
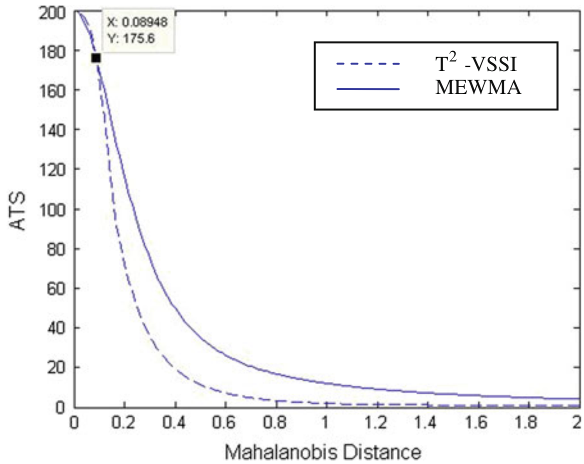


Fig. 69.6 ATS for T^2-VSSI and MEWMA ($p = 4$, $n_0 = 5$)



In Fig. 69.1, the performance of T^2-VSSI and MEWMA is compared. So is Figs. 69.1, 69.2, 69.3, 69.4, 69.5 and 69.6. In Fig. 69.1, we can see when $d = 0.55$, ATS of MEWMA and T^2 with VSSI is equal. And when d is less than 0.55, MEWMA has lower value of ATS, which means that the statistical properties of MEWMA are better. On the other hand, T^2 with VSSI is optimal. In the following Tables 69.1 and 69.2, some optimal sampling schemes of the control charts are listed when d is 0.25, 0.5 and so on.

Figure 69.2 and Table 69.3 shows the comparison when $p = 2$, $n_0 = 3$.

Figure 69.3 and Table 69.4 shows the comparison when $p = 2$, $n_0 = 5$.

Figure 69.4 and Table 69.5 shows the comparison when $p = 4$, $n_0 = 2$.

Figure 69.5 and Table 69.6 shows the comparison when $p = 4$, $n_0 = 3$.

Table 69.1 Optimal sampling schemes for T^2-VSSI ($p = 2$, $n_0 = 2$)

d	n_1	n_2	a	w	ATS
0.50	1	40	1.02	6.96	30.19
0.75	1	14	1.08	4.95	10.64
1.00	1	7	1.20	3.37	4.66
1.25	1	4	1.60	1.82	2.49
1.50	1	3	2.80	0.81	1.59

Table 69.2 Optimal sampling schemes for MEWMA ($p = 2$ and 4, $n_0 = 2$)

d	$p = 2$			$p = 4$		
	r	h	ARL	r	h	ARL
0.50	0.10	8.64	28.09	0.10	12.73	35.14
0.75	0.10	8.64	15.17	0.10	12.73	18.51
1.00	0.14	9.16	9.97	0.12	13.06	12.06
1.25	0.19	9.57	7.14	0.17	13.62	8.61
1.50	0.25	9.89	5.43	0.22	13.97	6.51

Table 69.3 Optimal sampling schemes for T^2-VSSI ($p = 2$, $n_0 = 3$)

d	n_1	n_2	a	w	ATS
0.50	1	34	1.06	5.43	16.54
0.75	1	13	1.19	3.46	5.71
1.00	1	7	1.51	2.01	2.67
1.25	2	4	2.80	0.81	1.63
1.50	2	4	2.80	0.81	1.23

Table 69.4 Optimal sampling schemes for T^2-VSSI ($p = 2$, $n_0 = 5$)

d	n_1	n_2	a	w	ATS
0.50	1	29	1.15	3.80	8.40
0.75	2	13	1.36	2.48	2.99
1.00	2	7	2.80	0.81	1.56
1.25	4	6	2.80	0.81	1.18
1.50	4	6	2.80	0.81	1.06

Table 69.5 Optimal sampling schemes for T^2-VSSI ($p = 4$, $n_0 = 2$)

d	n_1	n_2	a	w	ATS
0.50	1	52	1.02	11.19	40.84
0.75	1	18	1.06	8.84	15.41
1.00	1	10	1.12	7.27	6.80
1.25	1	6	1.26	5.66	3.53
1.50	1	3	2.80	2.37	2.05

Table 69.6 Optimal sampling schemes for T^2-VSSI ($p = 4$, $n_0 = 3$)

d	n_1	n_2	a	w	ATS
0.50	1	46	1.04	9.52	22.68
0.75	1	18	1.12	7.20	8.06
1.00	1	9	1.33	5.17	3.67
1.25	1	5	2.20	2.91	2.03
1.50	2	4	2.80	2.37	1.41

Table 69.7 Optimal sampling schemes for T^2-VSSI ($p = 4$, $n_0 = 5$)

d	n_1	n_2	a	w	ATS
0.25	1	205	1.02	11.19	50.69
0.50	1	40	1.10	7.58	11.46
0.75	1	15	1.38	4.89	4.06
1.00	2	8	2.08	3.06	1.97
1.25	3	7	2.20	2.91	1.32
1.50	4	6	2.80	2.37	1.11

Figure 69.6 and Table 69.7 shows the comparison when $p = 4$, $n_0 = 5$.

From the comparisons of the figures, T^2-VSSI is the better choice when Mahalanobis Distance is larger. However, if Mahalanobis Distance is small, MEWMA chart is optimal.

As the sampling number n_0 is larger, the performance of T^2-VSSI is better. On the other hand, as the quality properties increase, MEWMA is better to inspect the change of the mean vector. So, the statistical properties of T^2-VSSI can be improved by a larger n_0 and a smaller p.

69.5 Conclusion

In this paper, we introduce the approach of Markov Chain to calculate the ARL for MEWMA chart and ATS for T^2-VSSI. The parameters of the control charts are studied to make sure that the sampling scheme is feasible. Then different values of some parameters are studied to get the optimal sampling scheme which makes ATS or ARL minimum.

When we compare these control charts, the statistical properties are affected by Mahalanobis Distance. When d is small than 1, the MEWMA is always the better choice. However, T^2-VSSI is the optimal one when d is larger.

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Chapter 70
Evaluation of the Degree of Customer Satisfaction of Auto Maintaining Industry Based on Quality Function Deployment

Qiao-yun Wu, Gang Chang and Hua Yang

Abstract The Quality Function Deployment (QFD) method is introduced into the research on the evaluation of the degree of customer satisfaction of auto maintaining industry and the QFD model for evaluation of the degree of customer satisfaction is constructed. The multistage QFD model resolves the general degree of customer satisfaction into some comprehensive indexes and evaluates the customer satisfaction index (CSI) afterwards. The experiment proves that the method is effective and intuitionistic.

Keywords Degree of customer satisfaction · Quality function deployment · House of quality

70.1 Introduction

The competition of auto maintaining industry is more and more drastic with the development of auto industry. The topic of advancing the degree of customer satisfaction and fostering the lasting and genuine loyalty of customer is the hotspot of auto maintaining industry. The evaluation of the degree of customer satisfaction has more and more attention of researchers and enterprisers.

The earliest evaluation model of the degree of customer satisfaction is the econometrical model on of satisfaction index of Swedish customers developed by Fornell (Mihelis et al. 2001; Fornell 2008; Zhang 2002; Grigoroudis and Siskos 2003). The model is based on five factors that are customer expectation, customer apperception, customer satisfaction, customer loyalty and customer complaining.

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Fornell, John, Aderson, Cha and Bryant built the econometrical model for satisfaction index of American customers on six factors that are apperception quality, apperception merit, customer expectation, customer satisfaction, customer loyalty and customer complaining based on the Swedish model (Spreng et al. 2006). Firstly, the model embeds the factors influencing the degree of customer satisfaction into a causality system. Secondly, it determines the relationship between the factors and CSI by use of the statistical analysis and demonstration results. Then the weight and the indexes that have relation with the degree of customer index are obtained by use of multivariable linear regression. Lastly, the evaluation method of the degree of customer satisfaction is got. Johonson et al. (2001) built the Norwegian model by revising the American model and do the Empirical research (Eklof 2000). Nowadays, the researches on the Fornell model are focus on the revise, improvement and extension based on different data and measurement methods.

The research on the measurement of customer satisfaction focuses on analyzing a number of factors affecting customer satisfaction and constructing the evaluation index system of the degree of customer satisfaction. The evaluation model on the degree of customer satisfaction is established and evaluated base on it (Cui 2008). The econometrical model can hardly obtain the weight of the factors via the direct expression and make it difficult to analysis, and diagnose of the reason of customer dissatisfaction. QFD is a tool for analyzing customer needs and translating them into requirements for product design and quality analysis (Yoji 1990). It describes the relationship between customer needs and product design specifications in the form of matrix chart, and does quantitative analysis of the relationship (Hongen 2002; Adiano and Roth 1993; Fornell et al. 1996). It can be understood as the analysis tool to decompose in the form of matrix and quantitatively analyze the relationship among a variety of evaluation indexes. With the help of the QFD method, the article quantitatively analyzes the relationship between the factors of customer satisfaction evaluation and impact assessment indicators and the relationship between the various influencing factors by use of the relationship matrix and correlation matrix in the matrix chart. It decomposes the overall degree of customer satisfaction into easy-to-judging customer satisfaction index gradually through the multi-stage quality function deployment. Then the index system for customer satisfaction evaluation is constructed. At last, the intuitive and convenient evaluation index of customer satisfaction of all levels and overall customer satisfaction index CSI by use of house of quality of QFD model.

70.2 Methodology

70.2.1 Customer Satisfaction Measurement Model

To achieve the purpose to measure Customer Satisfaction, it is needed that evaluation of overall degree of customer satisfaction and determining the CSI. Firstly, a index system for customer satisfaction evaluation should be established to understand the factors influencing the overall degree of customer satisfaction and the relationship between these factors (Dick and Basu 1994). The House of Quality of customer satisfaction evaluation visually shows the correlation between satisfaction measurement indicators and influencing factors and the relationship of various factors. The relationships are used to decompose the customer satisfaction evaluation index into its influencing factors or evaluation index.

In order to facilitate the analysis, the factors influencing the overall degree of customer satisfaction are referred to as first-level index and the factors influencing first-level index are referred as second-level index, and so on. In this way, the overall customer satisfaction measurement index can be gradually decomposed into easy-to-judging satisfaction evaluation index by use of the house of quality customer satisfaction evaluation model as shown in Fig. 70.1 (Chen 2009). The stage of the decomposition of the customer satisfaction QFD evaluation model or the number of house of quality can be determined according to the degree of difficulty of the practical problems and different hierarchical customer satisfaction evaluation system are formed in different stages of QFD.

The overall degree of customer satisfaction can be decomposed into hierarchical evaluation system according to the relationship between the lower level indexes and the upper level indexes of customer satisfaction. In actual survey of the degree of customer satisfaction, two-level indexes of customer satisfaction can clearly articulate satisfaction judgments of the customers under normal circumstances. Taken the two-stage of QFD evaluation model as example, the evaluation model for the degree of customer satisfaction is built as Figs. 70.2 and 70.3.

p_{ij} is referred as the degree of the association between first-level i-th indexes and the allover degree of customer satisfaction, $w_i^{(1)}(i = 1, 2 \ldots n_1)$ is referred as the importance of first-level i-th index to the degree of customer satisfaction,

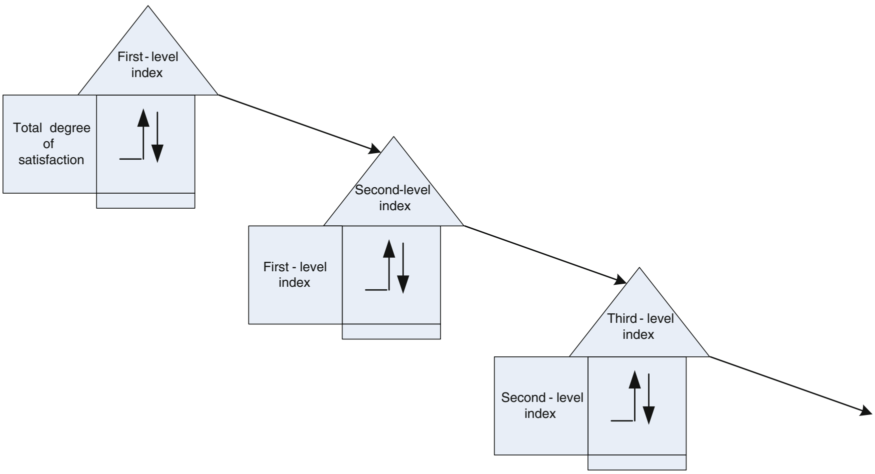

Fig. 70.1 Customer satisfaction measurement model

Fig. 70.2 House of quality for first-stage evaluation model for the degree of customer satisfaction

	The importance of index	First-level Index 1	First-level Index 2	…	First-level Index n
Allover degree of satisfaction	1	$r_{11}^{(1)}$	$r_{12}^{(1)}$	…	$r_{1n}^{(1)}$
The importance of first-level indexes $W_i^{(1)}$		$w_1^{(1)}$	$w_2^{(1)}$	…	$w_n^{(1)}$
Allover degree of customer satisfaction c Allover customer satisfaction index CSI		$c_1^{(1)}$	$c_2^{(1)}$	…	$c_n^{(1)}$

$c_i^{(1)}(i = 1, 2 \ldots n_1)$ is referred as the contribution of first-level i-th index to the allover degree of customer satisfaction.

$r_{ij}^{(2)}(i = 1, 2 \ldots, n; j = 1, 2 \ldots, m)$ is referred as the degree of the association of the i-th second-level index with j-th first-level index, $p_{ij}(j = 1, 2 \ldots, m)$ is referred as the measurement of satisfaction of the j-th second-level index to the i-th first-level index.

The house of quality of second-phase customer satisfaction measurement model characterizes the bottom indexes and the evaluation results of customers on indexes. The first-level evaluation index got in first phase is put on the left wall of the house of quality such as Fig. 70.3 and the first-level index are decomposed into second-level index according to the relationship $r_{ij}^{(2)}(i = 1, 2 \ldots, n; j = 1, 2 \ldots, m)$. Since the second-level indexes are the easy-to-judging indexes, the evaluation matrix constructed on these indexes is put in the basement of the house of quality. The importance of the second-level indexes to customer satisfaction is put on the top of the basement. The importance of the first-level indexes to customer satisfaction is put on the left wall of the basement.

70.2.2 Customer Satisfaction Measurement method

(1) *Constructing relation matrix*: The relation matrix is usually split into 0–9 grade as shown in Table 70.1. When $k = 1$, $k - 1$ level indexes is the allover customer satisfaction.

(2) *Determining judgment matrix*: According to the judgment of the results of the second-level indexes and their relationship with first-level indexes of customer satisfaction, the elements of judgment matrix p_{ij} were determined. The second-level indexes of satisfaction are the lowest level of indexes and easy to judge. Usually, the scope of the evaluation [min $e \sim$ max e] is given and the customer directly evaluates the index as in:

Fig. 70.3 House of quality for second-stage evaluation model for the degree of customer satisfaction

	The importance of index	Second-level Index 1	Second-level Index 2	…	Second-level Index n
First-level index 1	$w_1^{(1)}$	$r_{11}^{(1)}$	$r_{12}^{(1)}$	…	$r_{1m}^{(1)}$
First-level index 2	$w_2^{(1)}$	$r_{21}^{(1)}$	$r_{22}^{(1)}$	…	$r_{2m}^{(1)}$
…					
First-level index n	$w_n^{(1)}$	$r_{21}^{(1)}$	$r_{22}^{(1)}$	…	$r_{nm}^{(1)}$
The contribution of $w_j^{(2)}$		$w_1^{(2)}$	$w_2^{(2)}$	…	$w_m^{(2)}$
Satisfaction of first-level index 1		p_{11}	p_{12}	…	p_{1m}
…					
Satisfaction of first-level index n		p_{n1}	p_{n2}	…	p_{nm}

$$p_{ij} = \begin{cases} p_{i_0 j} = e_j, when\, r_{i_0 j}^{(2)} = \max\limits_{0 \le i \le n} \left\{ r_{ij}^{(2)} \right\} & j = 1, 2, \ldots, m \\ 0,\ otherwise \end{cases} \tag{70.1}$$

$r_{i_0 j}^{(2)} (j = 1, 2, \ldots, n_2)$ is referred as the average of the second-level indexes of evaluation results of customer satisfaction, $r_{i_0 j}^{(2)} (j = 1, 2, \ldots, n_2)$ is referred as maximum relationship of the second-level indexes with first-level indexes.

(3) *Calculating the importance of indexes*: In the decomposition of allover degree of customer satisfaction measurement at each stage, the indexes with the strong correlation are merged or removed to reduce the number of indexes of the same level according to the of correlation matrix roof house of quality. In the house of quality of customer satisfaction measurement model in Fig. 70.3, the importance of the second-level evaluation indexes of customer satisfaction are calculated as in:

$$w_j' = \sum_{i=1}^{n_1} r_{ij}^{(2)} w_i^{(1)}, \quad j = 1, 2, \ldots m \tag{70.2}$$

According to the correspondence between the second-level indexes with first-level indexes, the importance of second-level index $w_j^{(2)}$ corresponding to the same first-level index respectively is normalized and the results are the importance of the second-level index to the customer satisfaction, $w_j^{(2)}$.

In the house of quality of customer satisfaction measurement model in Fig. 70.2, the value of the index is 1 because there is only one index of customer satisfaction on the left wall. Then:

Table 70.1 The relationship corresponding to 0–9

0	1	3	5	7	9	2, 4, 6, 8
No relationship	Weaker relationship	Weak relationship	Normal relationship	Close relationship	Very close relationship	Intermediate relationship

$$w_j^{(1)} = \frac{1}{\sum_{j=1}^{n_1} r_{1j}^{(1)}}, \quad j = 1, 2, \ldots, n \tag{70.3}$$

4) *Calculating the degree of customer satisfaction*: The calculation of CSI should start from the final-level indexes and calculate the degree of satisfaction of all levels of evaluation indexes sequentially. Finally, the overall CSI is obtained. In the two-stage QFD model of customer satisfaction, it begins from second-level house of quality and sums the multiplying results of elements of each row of second-level evaluation matrix with corresponding importance to get the the degree of customer satisfaction of first-level indexes as :

$$c_i^{(1)} = \sum_{j=1}^{m} p_{ij} w_j^{(2)} \; i = 1, 2, \ldots, n \tag{70.4}$$

The degree of customer satisfaction of first-level indexes $c_i^{(1)}$ is put in the basement of first-phase house of quality. The total degree of customer satisfaction C and CSI are got according to the formula (70.5) and (70.6).

$$C = \sum_{j=1}^{n} c_j^{(1)} w_j^{(1)} \tag{70.5}$$

$$CSI = \frac{c - \min e}{\max e - \min e} \times 100 \tag{70.6}$$

70.3 Application Example

A customer satisfaction survey is done on the customers of 30 auto maintenance shops in some city. According to the correlation between the indexes, the maintenance environment, standardized maintenance, service after repair, repair quality

Fig. 70.4 House of quality for first-stage evaluation model for the degree of customer satisfaction of auto maintaining industry

	The importance of index	Enviro-nment	Standar-dization	service after repair	repair quality	prices
Allover degree of satisfaction	1	3	5	5	9	8
The importance of first level indexes $W_i^{(1)}$		0.1	0.17	0.17	0.3	0.26
C=7.22 CSI=69.1		8.74	7.3	7.7	6.69	6.88

The important of first-level indexes		Cleanliness	transport facilities	parking space	checking time	the description of the problem	reason able change	repair time	warranty	attitude	cleaning after repair	technical level	the revision rate	on-time delivery	honest price	reasonable charges	price indication
Environment	0.1	9	7	5													
Standardization	0.17			3	5	9	7	3	1	3				3	3		
Service after repair	0.17		5						9	5	3	5	3		1		3
Repair quality	0.3	1		1	3	3	3		7		1	9	7	3		5	
Prices	0.26	3					5			1		3			7	9	5
The important of second-level indexes		0.41	0.32	0.27	0.21	0.30	0.42	0.07	0.61	0.26	0.13	0.52	0.31	0.17	0.31	0.47	0.22
Satisfaction of Environment CSI of Environment	8.74 86	8.9	8.7	8.4													
Satisfaction of Standardization CSI of Standardization	7.30 70				7.9	7.5	6.8	7.6									
Satisfaction of Service after repair CSI of Service after repair	7.70 74.4								7.5	8.6	6.8						
Satisfaction of Repair quality CSI of Repair quality	6.69 63.2											6.6	7.5	5.5			
Satisfaction of Prices CSI of Prices	6.88 65.3														7.3	6.4	7.3

Fig. 70.5 House of quality for second-stage evaluation model for the degree of customer satisfaction of auto maintaining industry

and maintenance prices are chosen as first-level indexes. There are 16 indexes such as Cleanliness, transport facilities, parking space, checking time, the description of the problem, reasonable change, repair time, warranty, the attitude of service, cleaning after repair, technical level, the revision rate, on-time delivery, honest price tag displayed, reasonable charges and price indication are chosen as questionnaire indexes, i.e., the second-level indexes. The results of the questionnaire are collated, also statistical credibility and validity test.

Two-phase QFD method is used to evaluate customer satisfaction. Seven experts rate on the relationship between the first-level indexes and second-level indexes as well as first-level indexes with customer satisfaction. The scope of score of the 16 s-level indexes is (Mihelis et al. 2001; Fornell 2008; Zhang 2002; Grigoroudis and Siskos 2003; Spreng et al. 2006; Johonson et al. 2001; Eklof 2000; Cui 2008; Yoji 1990; Hongen 2002). The two-stage houses of quality of customer satisfaction measurement model for auto maintaining industry are constructed according to the two-stage house of quality method as Figs. 70.4 and 70.5.

In the first stage of house of quality of evaluation model of the auto maintenance industry can be calculated according to the formula (70.5) and (70.6) and the total degree of customer satisfaction is 7.22. Then CSI can be calculated as:

$$CSI = \frac{7.22 - 1}{10 - 1} \times 100 = 69.1 \quad (70.7)$$

The evaluation results show that the CSI of auto maintenance industry is only 69.1. It means that customer is not satisfied with the auto maintaining industry in general. In particular, the customers obviously not satisfied with the quality of maintenance and repair prices. It can be seen from the quality of house in Fig. 70.5 that the degree of satisfaction for quality of maintenance and repair price are 6.69 and 6.88, respectively and the satisfaction index are only 63.2 and 65.3. The main reasons that leading to dissatisfaction are unprofessional technical level, too high price and maintenance technicians, however hard, the price is too high maintenance, repair fraud and cheating.

70.4 Conclusion

The article did the research on the customer satisfaction measurement of auto maintaining industry through the two-phase the quality function deployment by use of house of quality. By building the house of quality of customer satisfaction evaluation model for the auto maintaining industry house, the hierarchical relationship between the customers' total satisfaction indexes and evaluation indexes at all levels are visually shown and it is easier to analyze and process factors affecting customer satisfaction compared with other methods. It provides a new method for the customer satisfaction measurement.

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Chapter 71
Fault Diagnosis Based on Fast Independent Component Analysis and Optimized Support Vector Machines

Jie Yin, Zhen He and Yuan-peng Ruan

Abstract As an efficient tool, support vector machine (SVM) has advantage on over-fitting problem and the small-samples cases. For improving the classifier's performance, extraction feature is required. The fast fixed-point independent component analysis (FastICA) is applied for feature extraction. The parameters of SVM are optimized by particle swarm optimization (PSO). In this paper, an integrated framework of FastICA and PSO-SVM algorithm for fault diagnosis is presented. Compared with other predictors, this model has greater generality ability and higher accuracy.

Keywords Fault diagnosis · Fast independent component analysis · Particle swarm optimization · Support vector machine

71.1 Introduction

The task of fault diagnosis is to determine which fault occurred. The diagnosis is based on the observed analytical and heuristic symptoms and knowledge of the process (Isermann 2006). Many techniques such as Bayesian classification, Fisher distinguishing, artificial neural networks (ANN) and support vector machine (SVM), have widely used in fault diagnosis (Demetgul et al. 2009; Venkatasubramanian et al. 2003). SVM, as a supervised learning method, has advantage on over-fitting problem and small-samples cases, because it based on the Statistical Learning Theory (SLT) which is originally introduced by Vapnik (1999a, b). Actually, many cases of fault diagnosis are the lack of fault samples.

Recently, SVM has been very successful applied in fault detection, handwritten digit recognition, function estimation problems, and modeling of nonlinear

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dynamic systems (Lecun et al. 1995; Samanta et al. 2003; Vapnik 1999) and so on, nevertheless high dimensional, excessively correlative and useless information will reduce classifier's performance (Cao et al. 2003). Feature extraction and feature selection is required. Principal component analysis (PCA) and Independent component analysis (ICA) are popular feature selection methods. While ICA has a better performance (Cao et al. 2003), which not only allow to decorrelate variables, but also to reduce higher-order statistical dependencies (Lee 1998). Therefore, ICA can be used to deal with a non-Gaussian process which is more practical in a real-world environment. We adopt a fast fixed-point independent component analysis algorithm (FastICA) that is computationally light, robust, and converges very fast (Koldovský et al. 2006).

On the other hand, the efficiency of SVM classifier depends on hyper-parameters and kernel parameters, so it is an important issue to apply SVM that how to select these parameters. Against the randomness of SVM parameters selection, particle swarm optimization (PSO) as a popular algorithm based stochastic optimization technique (Ge et al. 2005; Lin et al. 2008), can search the global best value for SVM parameters.

In this paper, an integrated framework of FastICA and PSO-SVM algorithm for fault diagnosis is presented, which combines independent component analysis for feature selection and support vector machine optimized by PSO for identification of different fault classes.

The organization of this article is as follows. Section 71.2 briefly describes FastICA algorithm, SVM algorithm and PSO for Parameters Selection of SVM. Section 71.3 briefly describes the integration approach for fault diagnosis. An example is presented in Sect. 71.4 to illustrate the proposed approach.

71.2 Theories and Methods

71.2.1 FastICA Algorithm

Original ICA is a signal-processing technique to transform observed multivariate data into statistically independent components, which are expressed as linear combinations of observed variables (Girolami 1991; Jutten and Herault 1991). The original ICA algorithm is briefly reviewed as follow:

It is assumed that k measured variables $X = [x_1, x_2, \ldots, x_k]^T$ are expressed as the linear combination of m-dimensional non-Gaussian vector $S = [s_1, s_2, \ldots, s_m]^T$ whose components are assumed independent. The relationship between them is given by:

$$X = AS \tag{71.1}$$

where $A = [a_1, a_2, \ldots, a_m] \in R^{k \times m}$ is the unknown mixing matrix. Here, we assume $k \geq m$. The basic problem of ICA is to estimate the independent components S or the mixing matrix A from the observed data X without any information of S or A. Therefore, it is necessary to define the objective of ICA is to find a separating matrix W which is given as:

$$\hat{S} = WX \tag{71.2}$$

where the reconstructed matrix $\hat{S}$ becomes as independent as possible. The whitening transformation which is the first step of ICA is expressed as:

$$Z = QX \tag{71.3}$$

where $Q = \Lambda^{-1/2}U^T$, and U is an orthogonal matrix of eigenvectors that are generated from the eigen-decomposition of $R_X = U\Lambda U^T$. After the transformation we get

$$Z = Q \cdot X = Q \cdot A \cdot S = B \cdot S \tag{71.4}$$

where B is an orthogonal matrix, given that $E(ZZ^T) = BE(SS^T)B^T = BB^T = I$.

From Eqs. 71.2 and 71.4, the relation between W and B can be expressed as:

$$W = B^T Q \tag{71.5}$$

Therefore, the problem of estimate the mixing matrix A is transformed into that of estimate the orthogonal matrix B.

In this paper, we adopt the fast fixed-point algorithm (FastICA) that is developed by Hyvärinen and Oja (2000). This algorithm, one of the most widely used ICA optimization methods, is based on Newton iteration method to find the maximum of non-Gaussian (Hyvärinen 1999).

71.2.2 SVM Algorithm

Support vector machine (SVM), is a supervised learning method, which has been used for fault detection and fault diagnosis. SVM, which is based on mapping input data into a higher dimensional space, is desired to find a maximum separating hyperplane. This algorithm is briefly overview here.

Suppose a set of N input vectors $X_i \in R^n$ (i = 1, 2,…,n) correspond with labels y_i, where $y_i = \{1, -1\}$. For linear SVM, consider the separating hyperplane

$$H : y = w \cdot X + b = 0 \tag{71.6}$$

where w is a normal vector and b is a scale. The two hyperplanes are represented as:

$$\left.\begin{aligned} y = w \cdot X + b = +1 \\ y = w \cdot X + b = -1 \end{aligned}\right\} \tag{71.7}$$

or it can be presented as:

$$y(w \cdot X + b) \geq 1 \tag{71.8}$$

is parallel to H and the data points closest to the two parallel are called support vectors.

SVM tries to maximize the distance between the two parallel hyperplanes to separate two classes. For non-linear cases, the slack variable ξ_i and the error penalty C are taken to the formulation as follows:

$$\begin{aligned} &\min_{w,b} \frac{1}{2}\|w\|^2 + C\sum_{i=1}^{N}\xi_i \\ &\text{s.t.} \quad y_i(w \cdot X_i + b) \geq 1 - \xi_i, \\ &\xi_i \geq 0, i = 1, 2, \ldots, N. \end{aligned} \tag{71.9}$$

By introducing Lagrangian multipliersα_k,we get the dual optimization problem of (71.9) is as follows:

$$\begin{aligned} &\max \sum_{k=1}^{N}\alpha_k - \frac{1}{2}\sum_{i=1}^{N}\sum_{i=1}^{N}\alpha_i\alpha_j y_i y_j X_i \cdot X_j \\ &\text{s.t.} \quad 0 \leq \alpha_i \leq C, i = 1, 2, \ldots, N \\ &\sum_{i=0}^{m}\alpha_i y_i = 0. \end{aligned} \tag{71.10}$$

Then, we can construct a decision function for a classifier as follows.

$$f(X_i) = \text{sign}\left(\sum_{j=1}^{N}\alpha_j y_j K\left(X_i, X_j\right) + b\right) \tag{71.11}$$

where $K\left(X_i, X_j\right)$ represents the kernel function.

For non-linear SVM, there are many kernel functions which can be used: Linear kernel, Polynomial kernel and Radial basis function. The most common functions are Gaussian radial basis and polynomial, which are as follows:

$$k(X_i, X_j) = e^{-\left\|X_i - X_j\right\|^2/2\sigma^2}, \tag{71.12}$$

$$k(X_i, X_j) = (X_i \cdot X_j + 1)^d. \tag{71.13}$$

Here, we select Gaussian radial basis function to train SVM.

71.2.3 PSO for Parameters Selection of SVM

Particle swarm optimization (PSO), which is first introduced by Kennedy and Eberhart (1995), is a popular optimization algorithm. It finds the best value by sharing historical information and social information between the particle individuals. Since the efficiency of SVM classifier depends on its parameters setting, PSO can supply the global optimal values.

In PSO, each particle represents a potential position and can move to the best positions according to its fitness to the environment. To establish the optimization model of penalty parameters and kernel function parameters, the PSO algorithm is described as follows:

$$v_{ij}^{k} = wv_{ij}^{k-1} + c_1 r_1 (p_{ij}^{k-1} - x_{ij}^{k-1}) + c_2 r_2 (g_{ij}^{k-1} - x_{ij}^{k-1}) \quad (71.14)$$

$$x_{ij}^{k} = x_{ij}^{k-1} + v_{ij}^{k-1} \quad (71.15)$$

where p_{ij}^{k} and g_{ij}^{k} represent the best previous position of each particle and the best position in the whole swarm in the iteration t. c_1 and c_2 are nonnegative rate constants. r_1 and r_2 are generated random numbers in the interval [0, 1]. w is the inertia coefficient.

71.3 Diagnosis Algorithm of FastICA with PSO-SVM

The fault diagnosis based on FastICA and PSO-SVM is carried out as shown in Fig. 71.1.

FastICA can reduce the dimensions because of the basic idea that the measured variables are the mixture of some independent variables. Then, we should select

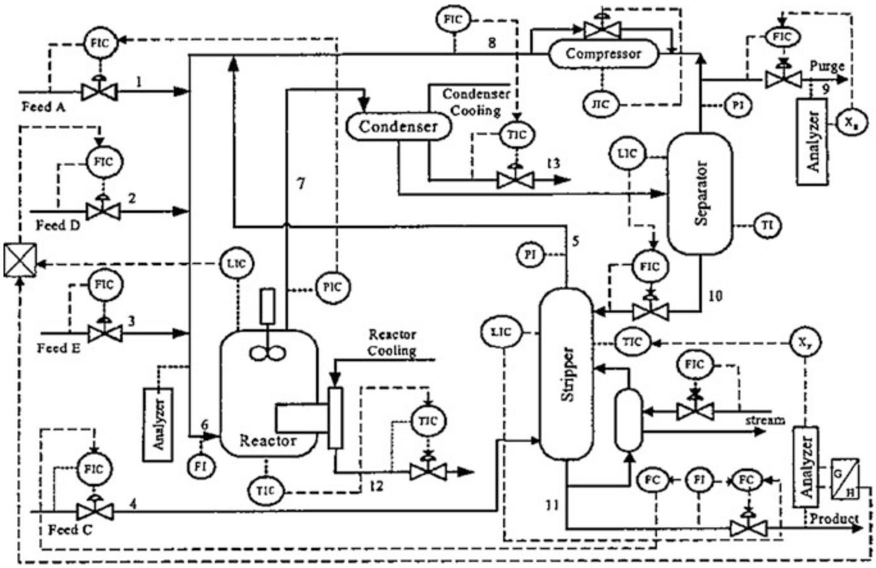

Fig. 71.1 A proposed approach for fault diagnosis algorithm

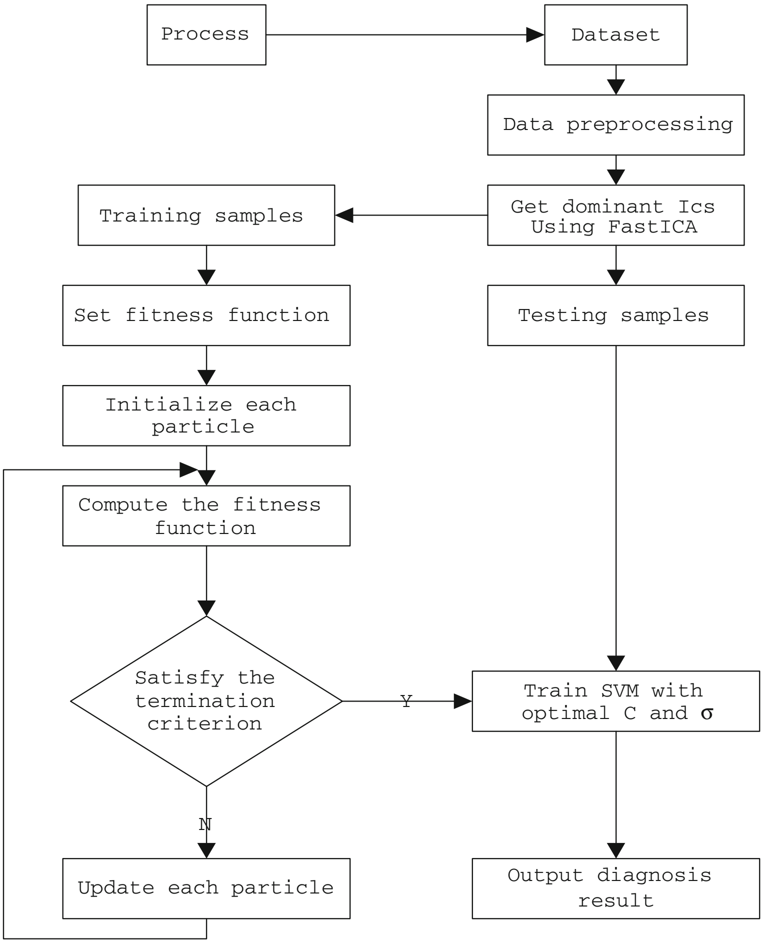

Fig. 71.2 The Tennessee Eastman process

some important components from all the independent components. In this paper we use a fast approximate search algorithm called Testing-and-Acceptance to ordering the independent components under a data reconstruction criterion (Cheung and Xu 2001). After the ordering, dominant independent components are chosen by an empirical number selection criterion, which is introduced by Cheung and Xu in detail (1999). By using of those methods, the original higher-dimensional measured inputs are transformed into lower-dimensional features. Then, SVM classifier is optimized by PSO for fault diagnosis.

Table 71.1 Comparison analysis of diagnosis algorithms

Diagnosis methods	SVM	PSO-SVM	FastICA with PSO-SVM
The accuracy rates (%)	80 %	88 %	98 %

71.4 Experiment Results

In this section, the proposed algorithm is applied to the Tennessee Eastman process faults classification. The basic process structure is show in Fig. 71.2, and the details of to the Tennessee Eastman process simulator are described by Downs and Vogel (1993). This process has 12 manipulated variables and 41 measured variables. We select two kinds of faults from a set of faults and produce 360 fault samples. Each class has 80 training samples and 100 testing samples. The diagnosis accuracy rate is the ratio of the number of samples classified correctly to the number of total samples. Table 71.1 shows the diagnosis accuracy rates by the methods of FastICA with PSO-SVM, PSO-SVM and SVM.

The results shown in Table 71.1 illustrates that proposed approach gives a result which is better than both of SVM and PSO-SVM.

71.5 Conclusion

This paper proposes a fault diagnosis approach integrated by the fast fixed-point independent component analysis to features extraction and support vector machine to fault sauces classification. This work combines particle swarm optimization algorithm, which is a global search algorithm to select the parameters of SVM, into the proposed approach. The application example shows that this approach can provide an accepted degree of accuracy in fault diagnosis, and it outperforms SVM and PSO-SVM approaches.

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Chapter 72
Information Management System for Engineering Equipment Quality Supervision Based on the Quality Files

Pin Duan, Yong Jin, Qi Guo, Lei Pang and Zhi-xin Jia

Abstract There are contradictions between the mode of equipment quality supervision of the military enterprises with the pace of development of modern weapons and equipment, so the management of equipment quality information must be standardized, accurate, and efficient. Information management system is based on the accurate collection of the quality problem in the equipment whole life from research and development phase to after-sales service. Based on the computer technology as a platform, forms the quality files and realizes the long-term effective information management across the enterprise with more equipment, under the network shared environment, so that the equipment quality supervision specified in a more efficient working methods.

Keywords Decision support · Information management · Quality file · Quality supervision

72.1 Introduction

In that weapons and equipment are the products from military enterprises, the rationality and effectiveness of the supervision are focuses of the management. Modern weapons and equipment are constantly upgrading, and the structure is more complicated with more and more powerful functions as well, which put forward higher requirements for quality supervision. However, there are three drawbacks in existing supervision model (John 1997; O'Neil 2000).

Firstly, with the old and new institutional adjustment and personnel turnover, new employees cannot grasp the same type of equipment quality information, or

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cannot fully grasp, cannot be targeted. According to the general quality problems repeated several times, the enterprise is supposed to prepare report and assessment (Liu 2007a). New employees, who are unfamiliar to the equipment quality information, once quality problem arises again, tend to be unable to effective determine, resulting in vulnerability management, leading to equipment quality declining, which will affect the users' normal use.

Secondly, for most military enterprises, the information resource management still remains in the traditional "one pen and a notebook" management model—manual testing, manual record, and repeatedly copying operation—resulting in low efficiency and investment much larger than the income (Liu 2007b). Binding, inspecting and reporting for frequent manual records and paper materials, supervision and inspection department is bound to involve most of the time and energy, affecting the timeliness and effectiveness of the equipment quality supervision. Without easy access to tens of thousands of test parameters and record can not be used, quality problems can not be foreseen, and quality trends can not be predicted, the means of work lags behind the quality control is very risky, and difficult to adapt to the requirements of modern enterprise development.

Meanwhile, with the popularity of computers, a computer of the military enterprises of manpower is uncommon. However, since there is no systematic, network design and planning from the outset, the computer management dispersed, only to provide word processing. Work experience, especially in military production and inspection process analysis, the typical failure mechanism is still preserved in the hands of individuals of the executives, which do not translate into improved overall level of wealth of the business. Computers don't transform into a network layout, and its function is far from being brought into full play, of which information resources cannot be shared, the formation of "islands of information" is serious.

Hence, the quality supervision informationization needs to be strengthened, resulting "information management system for equipment quality supervision" occurred, which is based on equipment quality files for the database, programming language to reflect real-time equipment quality conditions, and based on analysis and evaluation model of quality supervision, to provide decision support application software system (Yuan et al. 2003; Huang 1999).

72.2 Contents and Requirements

72.2.1 Research Contents

The purpose of this paper is to ensure the effectiveness and the timeliness of supervision of enterprise quality, prevent blind supervision with the consumption of energy, meet the enterprise complete control of the quality of the same type of equipment needed, and provide the basis for the supervision of similar products in the future (Yang and Zheng 2006).

The content of the information system are as follows.

Based on the product quality problem data classification in accordance with principles of defects divided, the entire information system to be completed by quality problems query, chart of quality supervision, data upload of new products and decision support functions as well. Meanwhile the network interface is available to the same operation in a networked machine, of which the information exchange platform of quality supervision can be funded to share information.

72.2.2 Research Requirements

The information management system of equipment quality supervision must meet the following requirements.

(1) *Realize the business process management*: When the information flow of software is designed, according to the regularization of business requirements, it is necessary to carefully comb the business information process module and the processing chain, introduce the project management methodologies (Song et al. 1997), and according to the order of scientific research, contract management, quality supervision and inspection, after-sales services, set up the logical order and strict project management permissions module in all aspects of information flow, of which the operator can automatically record and its operation. For each a setting job, only be assigned the management of projects, the information processing sequence, links and permissions, can the information be input, reviewed and modified. When the information and data that have been audited frozen are processed, the software system will automatically lock data to prevent changes, which makes the software business to maintain the timeliness, validity and traceability, and which standardized management of electronic business information.

(2) *Achieve real-time information input*: The improvements of the man–machine interface and the software ease the information input. Such as an easy-to-use intuitive interface with the input of key data accompanied by examples or reminders, and data import and export functions, which is available to business information both can be processed in the software, then exported to the other where it is needed, and data records away from the network test can be imported into the network database, to improve the practicality of the software.

(3) *Realize the intelligent judgment and statistical analysis*: Preset mathematical model of intelligent judgment and statistical analysis, to any need for information processing products, can initialized defined the standards of relevant parameters, inspection logic process, counting sampling plan in the software database server at any time by the administrator rights, according to the manufacture and acceptance requirements. This system can automatically collect and analyze one indicator parameter of product according to the required number of years and the batch, to assess the quality of a particular

indicator trends, as well as do the horizontal comparison of the different species products with similar parameters.

(4) *Realize the automatic prediction of assessment and decision support*: The function of this system also lies in building up the assisting assessment content and information association patterns, comprehensive quality management, assessment, and daily supervision and inspection of all kinds of information, and conducting the automatic correlation analysis, to generate the required statistical analysis of the chart to make predictions and judgments of product quality trends, given the trend of an issue or a particular indicator, auxiliary analyzing the possible causes, proposing measures and recommendations based on user needs, auxiliary generating quality analysis and other statistical charts.

(5) *Realize the report automatically generated and quickly passed* (Shi et al. 2005): The generation, transfer and printing of integrated report information fully considered the format generated, information conversion and transfer form between the information of statements and database, as well as between the upper and lower levels. The designation of open report designer is available to generating all the necessary report forms, which leads to the software front-end operating system from the database to automatically extract and summary report required information according to user needs; automatically generate or print reports. Apart from this, it is also able to automatically converse the report information of the network or removable media delivery to the same level or higher-level database, which makes the report generate and deliver more conveniently, faster and more efficiently.

72.3 System Realization

The function of the information management system for equipment quality supervision is mainly to set up the electronic quality files of product quality information, to avoid the inconvenience of paper material, and has certain ability of analysis and judgment based on large amounts of data. The system is mainly divided into five subsystems, quality problems import and export subsystem, quality problems query subsystem, statistical analysis subsystems, decision support subsystem, and network information sharing subsystem (Wang and Li 2004) (Fig. 72.1).

72.3.1 The Quality Problems Import and Export Subsystem

Using of the information management system for equipment quality supervision, it is inevitable to add new products or new quality problem into the system that provides two types of import information. User can directly copy to the specified

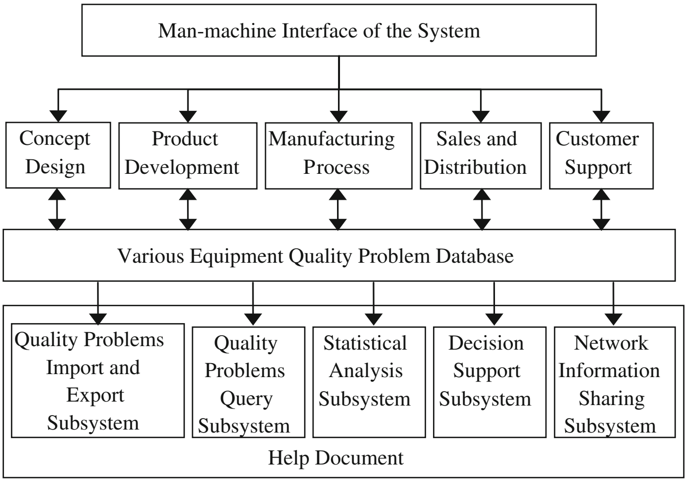

Fig. 72.1 General framework of information management system

Fig. 72.2 Raw data input

directory through the standard Excel report form and can import quality information guided by the system with an import module provided by the system as well. The second types of input information see Fig. 72.2.

When logging information management system for equipment quality supervision, according to the need of the operator, the query can be exported into Word or Excel report form, for other need or printout.

序号	名称	件号	年批	问题描述	发现单位	发现日期	发现工序	责任单位	总数量	不合格品数量	生产序号	问题产生原因	处理意见	缺陷类型	审理单编号	详细描述
1	连杆	02-4	2011	操作有误	13分厂	2011/2/22	13	13分厂	12	1		试程序造成	返修	轻缺陷	132011027	主视图右下角R73旁边有一处挖刀，尺寸7实测3.5，挖刀长度有17mm
2	连接杆	02-07	2011	夹屑	13分厂	2011/6/8	钻5	13分厂	11	2	20110010 20110017	在铰孔上夹屑	让步	轻缺陷	132011087	$\Phi 30^{+0.045}$实测$\Phi 30.09$一端内孔有坑0.1～0.2一周 $\Phi 30^{+0.048}$实测$\Phi 30.07$一端内孔有坑0.1～0.2一周
3	底座	04-02	2011	尺寸超差	36分厂	2011/4/14	车	36分厂	20	1	2011010	测量有误	让步	轻缺陷	362011010	尺寸$\Phi 1240^{+0.165}$实测1240.50
4			2011	操作有误	5分厂	2011/3/20	装焊	5分厂	20	1	20110016	操作失误焊接变形	让步	轻缺陷	520110003	中心位移1mm（尺寸850±1.5实测852.5）
5	高低机油管	04-05	2011	漏油	5分厂	2011/9/8	装配	5分厂	20	6		焊接过慢	返修	轻缺陷	162011038	漏油
6	方向机油管装配	04-06	2011	漏油	15分厂	2011/4/13	装配	15分厂	24	4		退刀端面粗糙	返修	轻缺陷	162011018	漏油

Fig. 72.3 Part of fault report of a product

72.3.2 The Quality Problems Query Subsystem

In the established information management system for equipment quality supervision, the operator has the access to query, learning related quality issues, to understand the level of product quality by entering the appropriate keywords. (The fault report of a product sees Fig. 72.3.)

72.3.3 The Statistical Analysis Subsystem

When the query subsystem completed, according to demand, the operator can conduct the relevant data with statistical analysis, using statistical analysis subsystem to obtain the quality information of a product, parts or products with the same raw material in a batch or in a few batches, and finally can be reflected visually through the form of graphs, charts (Wang et al. 2004).

Take a military enterprise for example; there are 21 types of products and spare parts in 2007. The number of "nonconforming processing sheet" is 773 in 2007, which is 48 % fewer than 1490 in 2006. The monthly statistical analysis is in Fig. 72.4.

According to the number of "nonconforming processing sheet" in Table 72.1, the troubles are caused from three ways of poor quality consciousness, poor operating awareness and Materials. Next batch, enterprise should strengthen the education of quality awareness, increase the intensity of technical ability training, and strictly review Materials (Wang 2000).

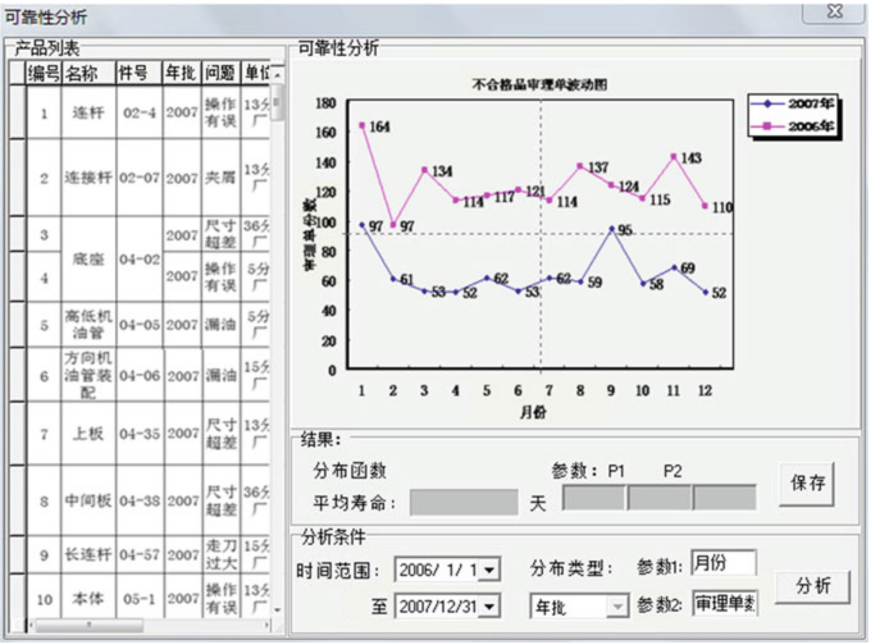

Fig. 72.4 Statistical analysis of the system

Table 72.1 Causes to troubles in 2007

Influencing factors		The number of "nonconforming processing sheet"		Rate(%)
Man	Poor quality consciousness	304	520	39.3
	Poor operating awareness	216		28.0
Machines		26		3.4
Materials		184		23.8
Methods		35		4.5
Environment		8		1.0
Sum		773		100

72.3.4 The Decision Support Subsystem

Through the given values of acceptable quality level (AQL) (National Quality Management and Quality Assurance Standardization Technical Committee 2003), calculate and predict the sampling information of next batch or next year, which provides a theoretical basis for quality supervision and decision-making.

For example, it is necessary to provide 1350 of "M16-2 × 60" this year, so the overall volume refers to "(72.1)".

批量			级别	正常检验			加严检验			放宽检验		
				抽样数量	AQL1.0		抽样数量	AQL1.0		抽样数量	AQL1.0	
			II		Ac	Re		Ac	Re		Ac	Re
2	~	8	A	2	↓		2	↓		2	↓	
9	~	15	B	3	↓		3	↓		2	↓	
16	~	25	C	5	↓		5	↓		2	↓	
26	~	50	D	8	↓		8	↓		3	↓	
51	~	90	E	13	0	1	13	↓		5	0	1
91	~	150	F	20	↑		20	0	1	8	↑	
151	~	280	G	32	↓		32	↓		13	↓	
281	~	500	H	50	1	2	50	↓		20	↓	
501	~	1200	J	80	2	3	80	1	2	32	1	2
1201	~	3200	K	125	3	4	125	2	3	50	2	3
3201	~	10000	L	200	5	6	200	3	4	80	3	4
10001	~	35000	M	315	7	8	315	5	6	125	5	6
35001	~	150000	N	500	10	11	500	8	9	200	6	7
150001	~	500000	P	800	14	15	800	12	13	315	8	9
500001	及其以上		Q	1250	21	22	1250	18	19	500	10	11

Fig. 72.5 AQL sampling standards

$$N = 1350. \quad (72.1)$$

According to the AQL sampling standards that have been entered into the system, looks up the rank are K as a general inspection level II; the sample size refers to "(72.2)".

$$n = 125. \quad (72.2)$$

Then the sample proportion refers to "(72.3)".

$$n/N = 125/1350 \approx 0.093. \quad (72.3)$$

If take the value of AQL for 1.0, then the acceptable (Ac) number is 3 and the rejectable (Re) number is 4 (Fig. 72.5).

If to retrieve the grant for two consecutive years without any quality problems, the system can suggest the user to relax the inspection, namely the sample proportion refers to "(72.4)".

$$n/N = 50/1350 \approx 0.037. \quad (72.4)$$

If take the value of AQL for 1.0, then the acceptable (Ac) number is 2 and the rejectable (Re) number is 3.

Fig. 72.6 User management

72.3.5 The Network Information Sharing Subsystem

Network (LAN or WAN) make the host information sharing, the extension by installing the client can login the information system, and operate the information search, upload and modify. In order to ensure the correctness of the information, integrity and prevent malicious changes, it is necessary to establish appropriate information management authority, and track the establishment of the recent work of all operating personnel. If modification and other operations for the information have been frozen are founded, the system will automatically lock (Fig. 72.6).

The system has also established a help document, which is convenient for novice, and makes this system used to the daily work faster and better.

72.4 Program

This system is designed and implemented in Visual C ++6.0 integrated development environment. The following code is the implementation procedures of the system login interface to login for different permissions. Figure 72.7 is the system login interface.

```
#include "stdafx.h"
#include "EquipmentManager.h"
#include "Login.h"
#ifdef _DEBUG
#define new DEBUG_NEW
#undef THIS_FILE
static char THIS_FILE[] = __FILE__;
#endif
//#define HIMETRIC_INCH 2540
```

```
//extern LOADING *loaddlg;
long UserFlag = 5;
//Login dialog
Login::Login(CWnd* pParent/* = NULL*/)
: CDialog(Login::IDD, pParent)
{
//{{AFX_DATA_INIT(Login)
//NOTE: the ClassWizard will add member initialization here
//}}AFX_DATA_INIT
}
void Login::DoDataExchange(CDataExchange* pDX)
{
CDialog::DoDataExchange(pDX);
//{{AFX_DATA_MAP(Login)
//NOTE: the ClassWizard will add DDX and DDV calls here
//}}AFX_DATA_MAP
}
BEGIN_MESSAGE_MAP(Login, CDialog)
//{{AFX_MSG_MAP(Login)
ON_WM_ERASEBKGND()
ON_WM_CTLCOLOR()
ON_BN_CLICKED(IDC_BUTTON, OnButton)
ON_WM_HELPINFO()
ON_WM_SIZE()
//}}AFX_MSG_MAP
END_MESSAGE_MAP()
```

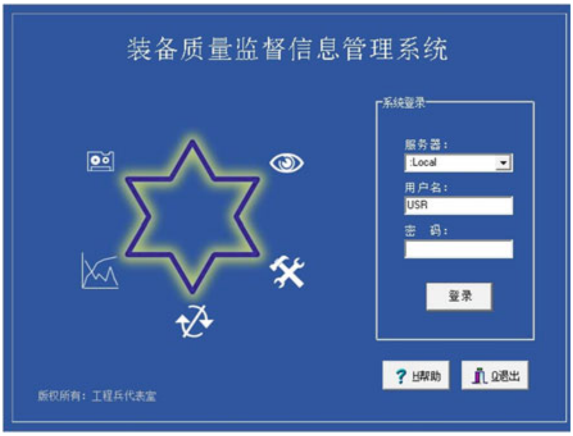

Fig. 72.7 The login interface of the system

72.5 Conclusion

This paper focuses on problems of quality information management in quality supervision at this stage, makes the model of information management system for engineering equipment quality supervision based on quality archives with the VC ++ platform. Various sub-systems of the information management system on the basis of applications, to meet the needs of the different types of enterprises, different kinds of equipment management and decision-making personality-oriented, make enterprises to improve product quality with very good results. The management philosophy of this system in some cases can be extended to the entire quality control in industrial engineering (Andre and Lavelle 1997; Hong 2002).

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Chapter 73
Leadership, Organizational Support, Shaping Process and Staffs' Behavior in Quality Works: An Empirical Study

Ning-ning Jing, Jia-xin Mao and Xiao-qing Chen

Abstract Staffs' behavior shaping is the focus and purpose of the construction of quality culture. This paper analyzes the relationship between leadership, organizational support, shaping process and staffs' behavior, verifies the theoretical assumptions and the conceptual model using structural equation modeling (SEM). The results show that shaping process has a significant direct positive impact on staffs' behavior, leadership has a significant direct positive impact on organizational support, leadership and organizational support have a significant direct positive impact on process shaping and also have a significant indirect positive impact on staffs' behavior through shaping process.

Keywords Construction of quality culture · Leadership · Organizational support · SEM · Shaping process · Staffs' behavior

73.1 Introduction

Quality culture, an important part of organization culture, reflects the beliefs and values of an organization in the process of meeting customer needs (Quality Culture In European Universities: A Bottom-Up Approach 2002). Organizations in America and Japan pay attention to construction of quality culture relatively early then in other countries. The feature in America is strategy, standard and system, and in Japan is people-oriented, which combines the rigidity of systems with the initiative of people (Luo 2011). In the construction of organizational quality culture, the foundation is staff participating, and the focus and purpose are staffs' behavior shaping.

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Some scholars have extensively researched the factors affecting staffs' behavior in quality works. Leadership can affect the concentration of organizational resources and the policies of human resource, so the promotion from the senior leaders is an important guarantee to change staffs' behavior. The works of leadership in the construction of organizational quality culture include formulating and implementing strategies, promoting and propagating quality culture, developing the communication among staffs and supervising quality (Quality Culture In European Universities: A Bottom-Up Approach 2002). Choy found that leadership has an indirect impact on staffs' behavior (Choy 2002). The change of staffs' behavior needs a top-down - pressure from leadership and some certain conditions from organizational support. According to organizational support theory, organizational support can meet staffs' social-emotional needs. If staffs can feel the willing and the rewards of organization, they would like to pay more efforts for the interests of the organization (Davis-LaMastro 1990). Douglas and others pointed that organizations should create an environment and some opportunities to develop the quality awareness (Douglas Fil 2009; Collins 1996). Liker and Hoseus believe that Toyota had achieved the human resource management support to promote the construction of quality culture by means of the long-term employment relationship, and the equitable consistent human resources policies and their practices (Liker and Hoseus 2009). Luo considers that we could enhance staff's quality awareness and shape their behavior by the following processes: education and training, communication, behavior criterion and system construction, and morale promotion (Luo 2009). Of the four processes above, education and training are very important in forming staffs' quality awareness, so we must not only make staffs master the quality management theory and tools, but enhance their quality moral and quality value through this process (Li 2007). Woods thinks that an important aspect of the construction of organizational quality culture is building a system that contains suppliers, staffs and customers. Communication is beneficial to build a consistent quality culture environment in and out of an organization, and to make staffs' behavior consistent (Woods 2010).

According to the author's previous researches, to shape staffs' behavior, leadership is premise and motivation, organizational support is foundation and sponsion, and shaping process is the key process (Jing and Chen 2011). By means of the method of structural equation modeling (SEM), and with 150 effective questionnaires, this paper made an empirical study on the relationship between leadership, organizational support, shaping process and staffs' behavior.

73.2 Theoretical Analysis and Assumptions

Staffs' behavior in the daily work and life embodied in the aspects of attitude, the quality assurance, the collaboration and communication, the team sprit, the learning and innovation capacity, the system thinking and so on. Some scholars have carried out extensive researches on how to shape staffs' behavior. They found that leadership, organizational support and shaping process are the three key factors that affected staffs' behavior (Collins 1996; Luo 2009; Irani et al. 2004; Harvey and Stensaker 2008; Naor et al. 2008).

73.2.1 Leadership

Leaders who draw the quality visions and formulate quality policies are organizers and drivers of quality functional activities and quality tasks (Li 2007). In these processes, they can make efforts to shape staffs' behavior consciously and imperceptibly. Leaders should provide appropriate guidance and supports for shaping staffs' behavior. On one hand, leaders should lead by example and promote actively, to set an example for staffs and guide their behavior. On the other hand, leaders should authorize staffs and let them have the decision-making power and executive power, so that they can continue to focus on quality improvement, and this will provide incentive and motivation to staffs for shaping their behavior. If leaders cannot initiate, demonstrate, deploy actively and authorize properly, staffs will not see their willing and determination, and so they can neither feel driving force from the top layer nor stimulate their own power. To a certain extent, the organizational quality culture reflects the leaders' quality awareness and the leaders' behavior affects staffs' behavior. A leader is an advocate, an organizer, a promoter, and a practitioner in the construction of organizational quality culture. Therefore, we make the following assumptions:

H1. Leadership has a direct positive impact on organizational support

H2. Leadership has a direct positive impact on shaping process

H3. Leadership has a direct positive impact on staffs' behavior

73.2.2 Organizational Support

Organizational support mainly includes organizational strategy, organizational structure, human resource management and human-oriented quality management. The formulation of organizational strategy is a major approach to successfully implant quality culture in an organization. Without strategy, developing quality culture will be meaningless and negative. After organizational strategy has been formulated, the organizational structure should be adjusted and a management department to guide and standardize quality culture construction should be established (Quality Culture In European Universities: A Bottom-Up Approach 2002). Human resource management has a direct impact on the staffs' sense to organizational support, and can provide power to change or keep staffs' behavior. So, an appropriate human resource policy is the premise to quality culture construction. Human-oriented quality management recognizes and pays great attention to the role of people in quality activities. It create a good atmosphere for shaping staffs' behavior, such as building dynamic mechanism, pressure mechanism, constraint mechanism, assurance mechanism and environmental impact mechanism (Liker and Hoseus 2009; Wen and Li 2007). Therefore, we make the following assumptions:

H4. Organizational support has a direct positive impact on shaping process

H5. Organizational support has a direct positive impact on staffs' behavior

73.2.3 Shaping Process

The forming of staffs' correct quality behavior must undergo some shaping processes which include education and training, communication, and the construction of behavior criterions and systems (Jing and Chen 2011). Education and training is an important process for staffs' quality knowledge accumulation, in which we should not only make staffs to master the theory, methods and tools of quality management, but carry out the specialized training on quality awareness. Communication in quality culture construction is in favor of building a consistent quality culture atmosphere in and out of an organization, so that the correct staffs' behavior can be kept consistently (Zhang and Su 2002). An important aspect of the quality culture construction is to build a communication system including suppliers, employees and customers. The construction of behavior criterions and systems can constrain staffs' behavior, shape and keep an excellent behavior.

Shaping process has a direct impact on the three stages of the quality knowledge accumulation, the attitude changing and the behavior changing. Shaping process can change staffs' behavior in short terms and can shape staffs' behavior in long terms. Therefore, we make the following assumption:

H6. Shaping process has a direct positive impact on staffs' behavior.

73.3 Research Design

73.3.1 Research Framework

Based on the above theoretical assumptions, an initial model which reflects the relationship between leadership promoting, organizational support, shaping process and staffs' behavior was built and shown in Fig. 73.1.

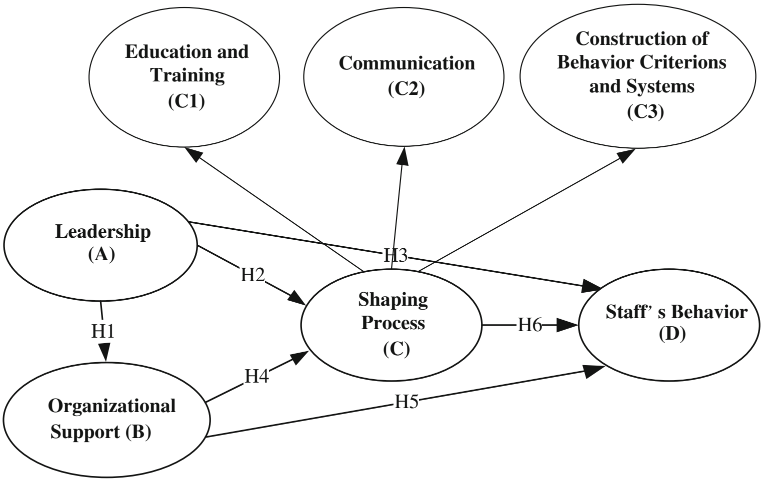

Fig. 73.1 The initial model

73.3.2 Research Sample and Measurement

Data were collected using questionnaires. Using multiple items, the questionnaire referenced existing scales as far as possible and increased new items according to the definitions of the measuring variables. After the preliminary design of questionnaire has been finished, the content, rationality and clarity of statements were tested by some quality experts and some quality managers in enterprises. And then the questionnaire was modified according to their suggestions. The reliability and construct validity of questionnaire were tested, and then the final items were determined, among them 4 questions are about leadership, 3 questions are about organizational support, 11 questions are about shaping process (3 about education and training, 4 about communication, 4 about construction of behavior criterions and systems), and 6 questions are about staffs' behavior. The items were measured using Likert 5 scale. The questionnaires were delivered and collected back with the help of author's colleagues, friends and students.

73.4 Empirical Analysis

73.4.1 Sample Statistics

In this investigation, the number of the companies containing machinery manufacturing, metallurgy, IT, consulting services and so on, was 21. 215 questionnaires were sent out and 173 were back. Among the 173 questionnaires, 150 are effective, the effective rate up to 69.8 %.

Among the 150 effective questionnaires, 11 % came from the companies having the awareness of quality culture construction but not yet depth development, 17 % came from the companies just starting quality culture construction, 28 % came from the companies that have shown signs of effectiveness in quality culture construction and is developing forward continuously, 44 % came from the companies that have excellent quality culture. The questionnaires from the companies that have mature experience about quality culture construction reach 72 %.

73.4.2 Sample Reliability and Validity Analysis

The reliability of scale was tested using the Cronbach's α. Under normal circumstances, the Cronbach's α is higher than 0.8, indicates that the reliability of the items is very good. The correlation between the items and the latent variables were characterized by the factor loading of the items. When the factor loading of items to their corresponding latent variables is all higher than 0.5, it indicates that this scale has a considerable convergent validity. The variance extracted (VE) of the latent variables to the items belonging to these scale is higher than 0.5, it indicates that the item is considerably on behalf of his latent variables. In the second-order model, Using average variance extracted (AVE) represents the convergent validity of latent variables. When the AVE of a latent variance is greater than or equal to 0.5, it indicates that the measurement of this latent variance has enough convergent validity. When the root mean square of AVE is higher than the correlation coefficient of latent variances, the discriminant validity is significant (Fomell and Lareker 1981). The analysis results of variables' reliability and validity can be seen in Table 73.1.

In the measuring process, the values of all Cronbach's α are higher than 0.8, the factor loading of each item is higher than 0.65, the VE of each latent variable is higher than 0.5. These suggested that the samples have reached an acceptable level.

Shaping process (C) is a second-order latent variable that is composed of three first-order latent variables: the education and training (C1), communication (C2), construction of behavior criterions and systems (C3). From Table 73.1, we can find that the AVE of each first-order latent variable is higher than 0.5, which suggests that there were enough convergent validity between the three. And at the same time, the Correlation coefficients of C1 and C2, C1 and C3, C2 and C3 are respectively 0.78, 0.70 and 0.60. Their squared values are respectively 0.62, 0.49 and 0.36. The correlation coefficient of two first-order latent variables is less than the AVE, which suggests that it has discriminant validity between C1, C2 and C3. So the education and training, the communication and the construction of behavior criterions and systems can completely express the connotation of shaping process.

Table 73.1 Reliability and validity

Latent variables		Items	Factor loading	Cronbach's α	AE	VAE
Leadership (A)		A1	0.89	0.91	0.80	/
		A2	0.81			
		A3	0.87			
		A4	0.86			
Organizational support (B)		B1	0.87	0.81	0.73	/
		B2	0.74			
		B3	0.69			
Shaping process (C)	C1	C11	0.78	0.90	0.83	0.76
		C12	0.93			
		C13	0.88			
	C2	C21	0.79	0.89	0.76	0.66
		C22	0.90			
		C23	0.78			
		C24	0.84			
	C3	C31	0.74	0.89	0.76	0.67
		C32	0.86			
		C33	0.88			
		C34	0.77			
Staffs' behavior (D)		D1	0.85	0.93	0.77	/
		D2	0.81			
		D3	0.78			
		D4	0.76			
		D5	0.89			
		D6	0.90			

73.4.3 Verification of Initial Model

AMOS 17.0 was used to estimate and test the path of initial model. Parameter estimation and fitting optimization index can be seen in Table 73.2. From Table 73.2, we can find that in the initial model, the significance level (P) of the path coefficient of leadership (A) to organizational support (B) has statistical significance at 0.01 level. The P of path coefficient of leadership (A) to shaping process (C) has statistical significance at 0.01 level. The P of path coefficient of organizational support (B) to shaping process (C) has statistical significance at 0.05 level. The P of path coefficient of shaping process (C) to staffs' behavior (D) has statistical significance at 0.01 level. The P of path coefficient of leadership (A) to staffs quality behavior (D) is 0.06 and the number of organizational support (B) to staffs' behavior (D) is 0.98. This suggests that the two paths do not reach statistical significance. So the assumptions of H3 and H5 are invalid.

According to the above results, the initial model was modified as sown in Fig. 73.2, in which the two paths with the P not reach statistical significance, were deleted. The correction model was tested, and the parameter estimation and fitting

Table 73.2 Parameter estimation and goodness of fit

SEM path	Index of initial model				Correction model			
	S.C.	S.E.	C.R.	P.	S.C.	S.E.	C.R.	P.
B←A	0.89	0.11	7.22	***	0.89	0.11	7.20	***
C←A	0.59	0.21	3.10	***	0.47	0.21	2.43	**
D←A	−0.82	0.40	−1.93	*	/	/	/	/
C←B	0.40	0.24	2.11	**	0.49	0.25	2.50	***
D←B	−0.01	0.36	−0.03	0.98	/	/	/	/
D←C	1.74	0.48	3.03	***	0.94	0.08	9.53	***
Goodness of fit	CMIN/df = 1.51, GFI = 0.76, NFI = 0.85, CFI = 0.94, RMSEA = 0.08				CMIN/df = 1.53, GFI = 0.76, NFI = 0.85, CFI = 0.94, RMSEA = 0.07			

Note *** $p < 0.01$; **$P < 0.05$; *$P < 0.10$

optimization index are shown in Table 73.2. We can see that the path coefficients of the modified model and the goodness of fit all reach the significant requirements.

73.4.4 Results

(a) The test results of theoretical assumptions can be seen in Table 73.3.
(b) From Fig. 73.2, in the composing variables of shaping process, the contributions of education and training, communication and construction of behavior criterions and systems are all large (0.85, 0.90 and 0.83, respectively).
(c) The influence effects of the correction model is shown in Table 73.4. we can see that the direct influence effect of leadership to organizational support is 0.89, the direct influence effect of leadership to shaping process is 0.47, the direct influence effect of organizational support to shaping process is 0.49, the

Table 73.3 Summary of test results about theotetical assumptions

Assumptions	Results
H1	Passed
H2	Passed
H3	Not passed
H4	Passed
H5	Not passed
H6	Passed

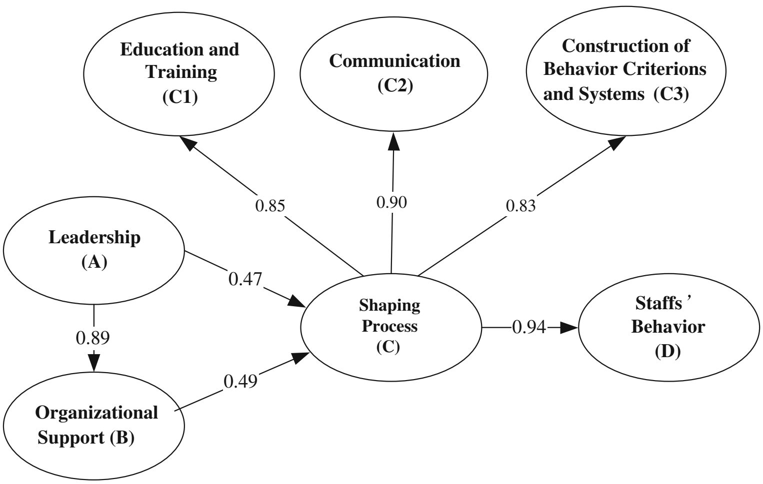

Fig. 73.2 The correction model

Table 73.4 The influence effects of the correction model

Path	Direct influence effect	Indirect influence effect	Total influence effect
Leadership → organizational support	0.89	–	0.89
Leadership → organizational support	0.47	0.44	0.91
Leadership → organizational support	–	0.85	0.85
Organizational support → shaping process	0.49	–	0.49
Organizational support → staffs behavior	–	0.46	0.46
Shaping process → staffs' behavior	0.94	–	0.94

direct influence effect of shaping process to staffs' behavior is 0.94, the indirect influence effect of leadership promoting to staffs' behavior through shaping process is 0.85, the indirect influence effect of organizational support to staffs' behavior through shaping process is 0.46.

73.5 Conclusions

Leadership has a significant direct positive impact on organizational support and shaping process, and has an indirect positive impact on staffs' behavior through organizational support and shaping process. These results indicate the importance role of leadership in construction of quality culture. Correct leadership will promote the reform of strategy, organizational structure and policies, and play a positive role in shaping process. The implementation and promotion of education and training, the establishment of the communication platform, the formulation and implementation of various systems would all need the promoting of leadership. So in the construction of quality culture, leadership is the premise and the power. In the construction of quality culture, Leadership should create an environment of open communication for staffs' participation. Leaders should participate in many kinds of quality culture activities together with staffs, help staffs understand the vision and values of organization clearly, give a strong support to the education and training, especially the training of staffs' quality awareness. In the construction of behavior criterions and systems, leadership should establish a perfect system in order to continuously improving staffs' behavior.

Organizational support has an indirect positive impact on staffs' behavior through shaping process. It should be known that staffs' behavior mainly rely on the implement by shaping process. Organizational support is the basis and guarantee of staffs' behavior, building a perfect organizational structure and management system are in favor of shaping process. Beginning with the change of staffs' quality awareness and values, staffs' attitude and behavior will be gradually changed, and become usual practice in their daily work.

Shaping process has a significant direct positive impact on staffs' behavior, and plays an intermediary role in the interaction of other factors to staffs' behavior. It suggested that shaping process is the indispensable process to shape staffs' behavior and is the key to the construction of quality culture. There are strong correlations between the education and training, the communication, and the construction of behavior criterions and systems. All of the three have large contribution to shaping process. The education and training, the construction of behavior criterions and systems need an effective communication platform, the education and training can promote communication and the construction of behavior criterions and systems, the construction of behavior criterions and systems can standardize the education and training as well as the communication. Therefore, only focusing on the three aspects of shaping process instead of the one or twos can effectively shape staffs' behavior.

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Chapter 74
On Fault Identification of MEWMA Control Charts Using Support Vector Machine Models

Li Li and Haiying Jia

Abstract Multivariate exponentially weighted moving average (MEWMA) control charts are widely used for detecting small mean shifts in manufacturing processes. However, the MEWMA control chart can only give out-of-control signals but provide no information on which variable or subset of variables that leads to the out-of-control signals. We propose a SVM (Support Vector Machine) based MEWMA fault identification model to help understand the underlying cause of the out-of-control signals. For each process variable, we build a SVM model for each variable to classify the out-of-control data of each variable into three classes: no mean shifts, downward mean shifts and upward mean shifts. The classification results are combined into the fault identification results. We also examine the effects of SVM parameters on classification performance and provide a SVM parameter optimization method.

Keywords Correct ratio · Fault identification model · MEWMA · Support vector machine

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74.1 Introduction

Statistical Process Control (SPC) is a widely used process monitoring technique for keeping processes under control. For key quality characteristics, SPC is designed to detect the evidence of whether or not there are shifts or changes (both in the process mean and variance) in manufacturing processes with proper sampling scheme.

In complex products manufacturing processes, it is quite common to simultaneously monitor several correlated quality characteristics. MSPC (Multivariate statistical process control) chart was proposed to monitor process with more than one correlated variables. The T^2 control chart was put forward by Hotelling (1947). It was tested that the T^2 chart is insensitive to minor shifts (Lowry et al. 1992). Thus the EWMA (Exponentially weighted moving average) and CUSUM (Cumulative Sum) charts were extended to multivariate process monitoring scenarios. The MCUSUM chart was introduced by Woodall and Ncube (1985), Healy (1987), Crosier (1988), Pignatiello and Runger (1990). The MEWMA chart was studied by Reynolds and Kim (2005), Zou and Tsung (2008).

With the application of computer technology in manufacturing processes and the enhancement of data collection technology, machine learning and data mining techniques have been used in multivariate process monitoring and fault identification. The artificial neural network (ANN) has been used as an effective tool for detecting the deviation of mean and/or covariance matrix in manufacturing processes (Guh 2007; Niaki et al. 2005; Wang and Chen 2002). Other related methods also have been used, such as the combination of ANN and Rough Set (RS) (Hou et al. 2003) and the combination of ANN and Genetic Algorithm (GA) (Yu and Xi 2009; Yu et al. 2008). A comparison of Support Vector Machine (SVM) and ANN for drug/nondrug classification has been done by Byvatov et al. (2003) and it was demonstrated that the SVM system used in the study has capacity to produce higher overall prediction accuracy than a particular ANN architecture.

In this paper we propose a SVM based model for fault identification in MEWMA control charts. The rest of this paper is organized as six sections. In the next section, a SVM-based MEWMA control fault identification model is introduced. Followed by the model training and testing results with scenarios of $p = 2$. Then we also examine the effects of two SVM parameters on the performance of MEWMA fault identification. Finally a summary on the paper is presented.

74.2 Methodology

There are two main modules in the SVM-based MEWMA fault identification model:

(1) Process monitoring. Firstly, we can estimate the process parameters, mean vector and variance–covariance matrix, using the collected historical process quality data (If the process parameters are all known, this step can be omitted). Then we can construct the MEWMA control chart based on the estimated parameters.

(2) Model training and testing. Using the estimated process parameters, we can generate random data with designed mean shift patterns. Then we can train and test the SVM model using the generated data. When there are out-of-control signals in the MEWMA control chart, the data are imported into the trained model. The output of the model will be the fault identification results which can be used to remove the fault in the manufacturing processes.

In the procedure of model training and testing, we must design different mean shift patterns. For each variable, we study three kinds of conditions, i.e. no mean shifts, mean shifts downwardly and mean shifts upwardly. For a process with p quality variables, there are totally 3p combinations include one in-control combination and 3p-1 out-of-control combinations. With the increase of p, the number of such combinations increases exponentially. We proposed a SVM-based MEWMA fault identification model here (see Fig. 74.1).

In the proposed model, we diagnose the variables independently. There are three kinds of outputs of each SVM, i.e. 1, 2 and 3. If there are no mean shifts in a variable, the output of the related SVM should be 1; if the mean of a variable shifts downwardly the output of the related SVM should be 2. The output of a SVM should be 3 if the mean of the related variable shifts upwardly. The number of SVM equals to the number of variables and the difficulties in model building is linear to the number of variables. Compared to the models reported by Guh[1] and Yu & Xi[5] in which the number of the classes of the output is 3p, the advantage of the proposed model is that the model building is much easier when p is large.

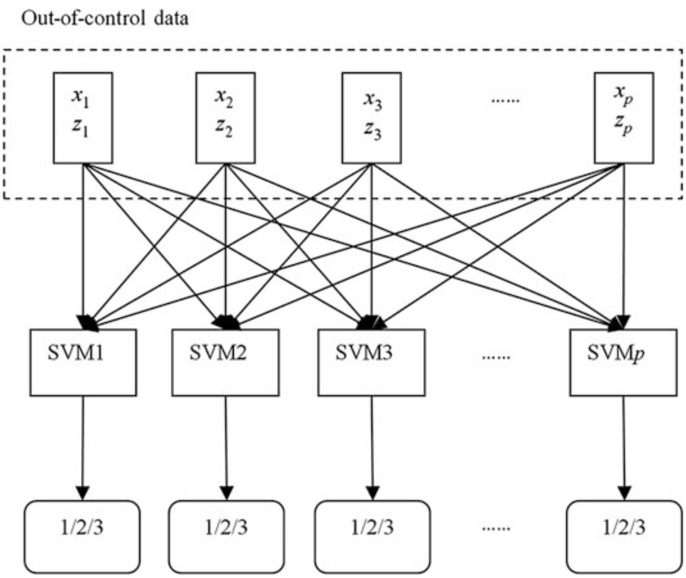

Fig. 74.1 A proposed SVM-based MEWMA fault identification model

74.3 SVM Training and Testing

The proposed model is built based on four assumptions. First, we assume that we can accurately estimate the mean vector and variance–covariance matrix of the process data given enough data. Second, there will only be mean shifts in the process while the variance–covariance matrix remains constant. Third, only abrupt shifts are considered here, which means that the data before and after shifts are all independently and identically distributed. Lastly, a process is assumed to remain in-control until a mean shift occurs. The shift will change the parameter estimation of the process data. We also assume that an out-of-control process will not become in-control until faults are found and removed.

74.3.1 Training and Testing Data Generation

Let $\boldsymbol{\mu}_0$ be the in-control process mean vector and $\boldsymbol{\Sigma}_0$ the in-control process variance–covariance matrix. A MEWMA control chart can be built if both parameters are known. The selection of smoothing factor and control limit of such a control chart is reported by Lowry et al. (Guh 2007). For presenting the interesting mean shifts intervals, we set the mean shift coefficients (k_1, k_2, …, k_p) to be the values of (−3.0, −2.0, −1.0, 0.0, 1.0, 2.0, 3.0). For a process with p variables, there are 7^p combinations include one in-control combination and 7^p-1 out-of-control combinations, denoted by M. We generated a set of random data using the multivariate normal random data generation function *mvnrnd*(.,.) in Matlab®. There were N_1 in-control samples and N_2 out-of-control samples in the generated data set. The data generation procedure is described as follows.

(1) Set $i = 1$ and generate N_1 in-control data.
(2) Generate out-of-control data $\mathbf{X}$ with a shifted mean vector. $\boldsymbol{\mu}_0 + \Delta\boldsymbol{\mu}$, where $\Delta\boldsymbol{\mu} = \left(k_{i1}\sigma_1, k_{i2}\sigma_2, \ldots, k_{ip}\sigma_p\right), k_{ij}, i = 1, 2, \ldots, M; j = 1, 2, \ldots, p$ is the ith mean shift coefficient of the jth variable, and $\sigma_i, i = 1, 2, \ldots, p$, is the standard deviation of the jth variable. The statistics $\mathbf{Z}$ and T^2 are calculated for each sample.
(3) Z is compared to the MEWMA control limits. If it is outsides the control limits, both $\mathbf{X}$ and $\mathbf{Z}$ are recorded.

Go to step 3 if the number of $\mathbf{X}$ is less than N_2, otherwise, set $i = i + 1$ and return to step 1.

For model testing, the mean shift coefficients are set to the values of (0.00, −1.15, −1.35, −1.55, −1.75, −2.25, −2.65, −2.85, −3.05, −3.25, 1.15, 1.35, 1.55, 1.75, 2.25, 2.45, 2.65, 2.85, 3.05, 3.25). The testing data are also generated using the above procedure.

74.3.2 SVM Parameters Selection

In this section we aim to determine the optimal SVM parameter values. To do that, we fix the process parameters and examine the effect of the SVM parameters on the performance of the proposed model. We consider an in-control process with $\boldsymbol{\mu}_0 = [0\,0]$ and $\boldsymbol{\Sigma}_0 = \begin{bmatrix} 1 & 0.5 \\ 0.5 & 1 \end{bmatrix}$. and set the number of in-control samples (N_1) to be 100. To build a SVM model, we construct a vector $\mathbf{V} = [\mathbf{X}\ \ \mathbf{Z}\ \ \boldsymbol{d}]$, where $\mathbf{X}$ is the raw data, $\mathbf{Z}$ is the MEWMA statistic of $\mathbf{X}$ and d is the classification label. We follow Lowry et al.'s suggestion (1992) that the smoothing coefficient of the MEWMA control and control limit h should be set to 0.1 and 8.66, respectively. The number of samples considered for each mean shift combination (N_2) is set to be 30.

As we discussed earlier, we use the Gaussian radial basis function as the SVM kernel function. There are two important parameters in the SVM model; including the penalty factor C and kernel function parameter b^2. We analyze the effects of these two parameters on the performance of our SVM models for fault identification with an example with two variables, i.e. $p = 2$. We select $C = 100$, 1,000, and 10,000, the values of b^2 are set to be in the range between 0.5 and 14.9 with an increment of 0.3. The correct ratio of both SVM1 and SVM2 are analyzed for the model training and testing. The testing results are presented in Fig. 74.2.

Figure 74.2 illustrates the performance of SVM for $C = 100$, 1,000, and 10,000. For each value of C, with the increase of b^2 the correct ratio values increase obviously and then reach the max value. After that the correct ratio values decrease slightly. And the correct ratio values with $C = 1{,}000$ and $C = 10{,}000$ are nearly the same when b^2 is greater than 5.

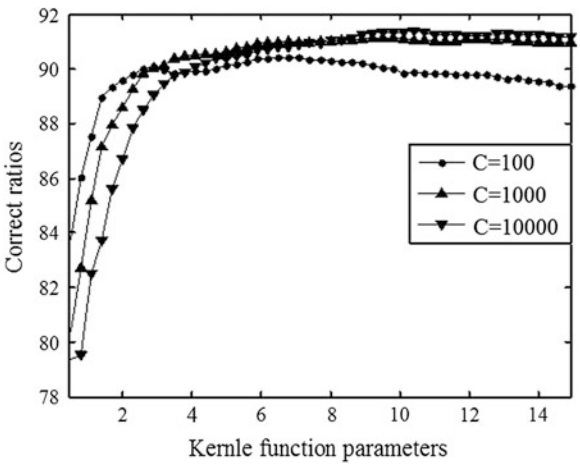

Fig. 74.2 The SVM training and testing performance with $C = 1000$ and 10,000

74.3.3 SVM Training and Testing Results

After choosing the optimal SVM parameters, we analyzed the performance of SVM training and testing given different correlation coefficients (ρ). We let the correlation coefficient be one of the following values (0.1, 0.3, 0.5, 0.7, 0.9). The SVM parameters are set to be $C = 10{,}000$ and $b^2 = 10.4$. We run the simulations for 1,000 times to each correlation coefficient value and the results are presented in Table 74.1. The correct ratios are also depicted in Fig. 74.3. It shows that the correlation coefficient do have effects on the performance of the SVM-based MEWMA fault identification model. When the correlation coefficient increases, the correct ratios of the SVM training decrease accordingly. The correct ratio of SVM1 training decreased from 94.22 % ($\rho = 0.1$) to 91.72 % ($\rho = 0.9$). The correct ratio of SVM2 training decreased from 94.33 % ($\rho = 0.1$) to 91.72 % ($\rho = 0.9$). Considering both SVM1 and SVM2, the overall correct ratio decreased from 88.57 % ($\rho = 0.1$) to 84.38 % ($\rho = 0.9$).

However, the correct ratio increases in the model testing while the correlation coefficient increased. The correct ratio of SVM1 testing increased from 92.99 % ($\rho = 0.1$) to 95.46 % ($\rho = 0.9$). The correct ratio of SVM2 testing increased from 93.03 % ($\rho = 0.1$) to 95.42 % ($\rho = 0.9$). Considering both SVM1 and SVM2, the overall correct ratio increased from 86.18 to 91.21 %. The average testing correct ratio was 88.57 %. Although the proposed approach achieved the highest correct ratio when the correlation coefficient was the highest, its performance is still acceptable when the correlation coefficient is small.

Furthermore, most of the variances in both training and testing results were relatively small. It shows that the performance of our model is stable under different conditions.

74.4 Summary

We proposed a MEWMA control charts fault identification model using SVM which is built on the concept of SRM. SVM has minor generalization errors compared to the approaches based on the concept of least-squares or maximum

Table 74.1 Effects of correlation coefficient on model performance

	Training performance			Testing performance		
	SVM1	SVM2	Overall	SVM1	SVM2	Overall
$\rho = 0.1$	94.22	94.33	88.57	92.99	93.03	86.18
$\rho = 0.3$	93.10	92.74	85.85	93.39	93.76	87.32
$\rho = 0.5$	92.39	92.22	84.76	94.16	94.18	88.46
$\rho = 0.7$	91.86	91.90	84.14	94.78	94.73	89.68
$\rho = 0.9$	91.72	91.72	84.38	95.46	95.42	91.21

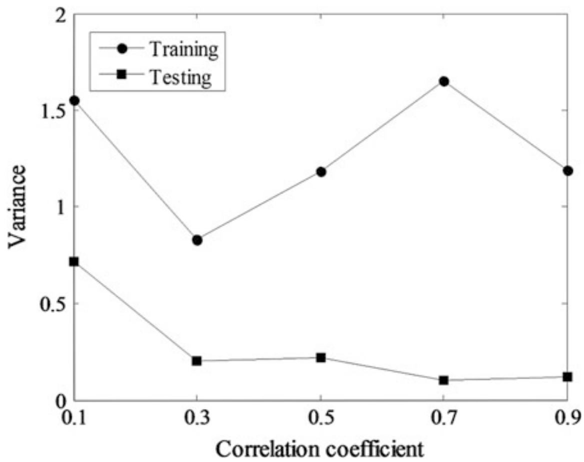

Fig. 74.3 Variances of SVM training and testing with different correlation coefficients

likelihood. After a brief introduction of MEWMA control charts and SVM, we gave an SVM-based model for MEWMA control chart fault identification when there are out-of-control signals in control charts. The raw process data X and the MEWMA of X are set as the input of the model and the process variables are diagnosed independently and this can reduce the difficulties of model building when the dimension of the problem increased.

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Chapter 75
Operation and Maintenance of Coal Conveying System Screening and Crushing Coal Machinery in Thermal Power Plant

Li-hua Zhao and Ming Liu

Abstract This paper based on our country current coal conveying system in thermal power plant, on the basis of typical screening and crushing mechanical equipment of analyzes the broken mechanics principle, expounds the typical screening and crushing mechanical equipment operation and maintenance which should pay attention to the problems and maintenance of key components.

Keywords Coal handling system ring, etc. thick roller screen · Hammer coal crusher, thermal power plant

75.1 Introduction

Coal screen and coal crusher are the key equipment of coal conveying system in thermal power plant (Lang 1998; Zhao et al 2001a, b). Coal conveying system usually set a screening crushing machine room; broken coal and screening equipment are used together, complete coal of broken and screening. Through such processing, meet the requirements of the particle size is sent to coal pulverizer into the following process. The screening and broken coal machinery as the key equipment of coal conveying system and responsible for the normal operation of the power plant to continually provide meet the requirements of the task of particle size of coal, in order to ensure the safety of the power plant production and the reliable operation of the coal conveying system, the first to ensure the screening and broken coal machinery and equipment safe, reliable and stable operation (Zhao et al 2003; Zhao 2011; Zhao et al. 2011).

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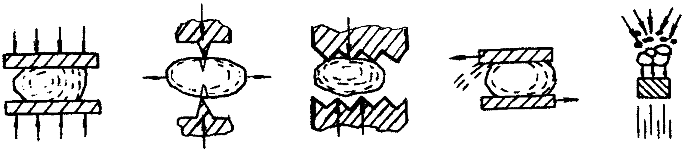

Fig. 75.1 Several roles in the form of broken coal machinery to material. *1*. Squeezing; *2*. Split; *3*. Fracture; *4*. Mill; *5*. Shredding

75.2 Shattering Process

Shattering process is the material of the external mechanical forces overcome material internal binding force, lump coal become small pieces of decomposing process. According to work-energy theorem, the work done of external mechanical forces for the material, make the material distortion, when reaching deformation energy storage limit, the material is broken. Several roles in the form of broken coal machinery to materia (Fig. 75.1).

Comprehensive broken mechanics process, major form of Shattering has five : squeezing, split, fracture, mill, shredding.

Broken coal mechanical sort is more, usually using one kind or several kinds of shattering process above. The more use of broken form for broken machinery, the better of broken. Now, coal crusher used in the coal handling system of domestic large and medium-sized power plant, according to their structural features can be divided into hammer type, strike back type and ring hammer type etc., which ring hammer coal crusher is more advanced models, high quality and efficiently fragmentation of anthracite coal, common coal, inferior coal and lignitous coal etc. Has not blocked, can eliminate impurity, has the advantages of simple structure, small in size, light weight, convenient maintenance etc. In each big, medium-sized power plant has been widely applied.

75.3 Screening and Crushing Coal Machinery

75.3.1 Crushing Coal Machinery

Take the HSZ-800 type ring hammer coal crusher as an example, the main structural features as shown in Fig. 75.2. Using the ring shaft 5 working with toothed hammer rings 4 active installations on the tumbler 6. In the second half of the week outside of machine body is equipped with the sieve frame 16, which consisted of crushing plate 18, arc-shaped sieve plate 17 and the small sieve plate 15 ect. The crushing cavity composed of rotor and crushed plate 18, arc-shaped sieve plate 17, which can be divided into three areas; upper part of the hit area, central (the lower crushing plate) extrusion area, bottom of (arc-shaped sieve)

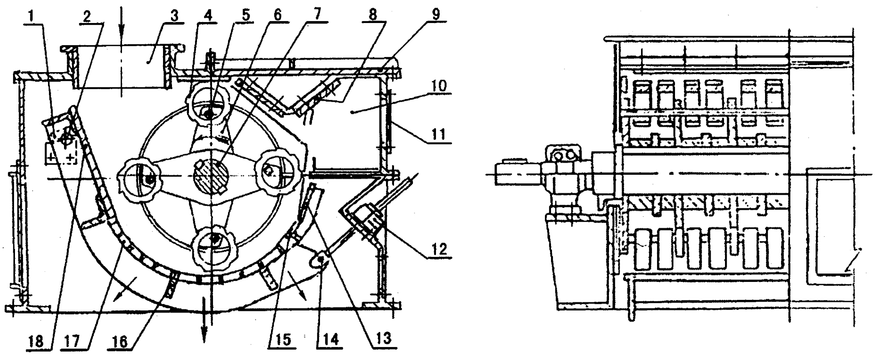

Fig. 75.2 HSZ-800 type ring hammer coal crusher *l*. limiting plate; *2*. hanging scroll; *3*. feed port; *4*. hammer ring; *5*. ring shaft; *6*. rotating arm; *7*. main spindle; *8*. baffle-board; *9*. machine cover; *10*. deironing room; *11*. sealed door; *12*. sieve frame adjusting device; *13*. dial plate; *14*. hinge pin; *15*. small sieve plate; *16*. sieve plate frame; *17*. arc-shaped sieve plate; *18*. crushing plate

milling area. In these three areas, material from the top feed port 3 into the crushe, between hammer rings and crushed plate, hammer rings and sieve plate, as well as material and material, were hit, impact, shear, extrusion and milling and other various forms of role, respectively, make the material to be shredding, split pieces, squeeze the broken and pulverize. The material being broken into required size, dropped from sieve gate hole of the cribriform plate, complete the crushing process. The grinding effect between hammer rings and sieve plate, which in favor of the qualified size material via the cribriform plate reseau is discharged out of the machine, for humidity larger coal, also not easy is clogging the phenomenon of reseau.

Hammer rings active installation, can free swing. When the coal mixed tramp iron, Woodblock or other not broken impurity, hammer rings along a radial direction of the rotor back automatically, make excellent impurity by a back hammer rings entrainment to the rotor on the right side of dial plate 13, collected in deironing room 10 by reflex plate 8, so that the machine has its own protection function. Open the sealed door 11 can remove tramp iron and other impurity; can also observe the wear of the ring hammer.

75.3.1.1 Features of the Ring Hammer Coal Crusher

(1) Rotor, which is equipped with spoke type rotary arm, thick and heavy, plays the role of the internal flywheel (Speed regulation and energy storage), with a larger kinetic energy. The ring hammer coal crusher take full advantage of the kinetic energy of the hammer rings, high-speed broken. High crushing, high efficiency, low energy consumption. Power consumption per ton is only 0.4–0.6 kWh/T, about half of the impact coal crusher, hammer coal crusher third.

(2) The size of broken particle is adjustable, and easy to operate. To ensure the nesting size and uniform particle size less than 25–30 mm, adaptable to coal changes, and can broken any coal, other types of crushers is difficult to achieve.
(3) Hammer rings swing freely, dial plate, deironing room (impurity warehouse) are the unique of ring hammer coal crusher, the ring hammer coal crusher is also applicable if the Iron, stone, wood and other impurity mixed in the coal.
(4) Rotor without self blast effect, and the space is compact, Using different interval differential pressure inside of the machine to perform reflux. Equipped with air volume control panel to feed port is slightly negative pressure, dust does not leak inside the machine, and favorable for environment protection.

In short, the ring hammer coal crusher have more advantages than other coal crushers, there are broad prospects for development of applications.

75.3.1.2 The Main Components and Their Effects

(1) Adjusting device between sieve plate frame and sieve plate.
Sieve plate frame 16 is welded into stents with the steel plate, it is mainly used to install crushing plate 18 and arc-shaped sieve plate 17 and other component, bear all broken force. The top of the Sieve plate frame is installed in machine body with hanging scroll 2, and limited fixed with snap-gauge 1. The lower right corner of sieve plate frame is hinged up with hinge pin 14 and sieve plate adjusting device.
Two sieve plate adjusting device which is installed on the right side of the machine body is used to adjust gap size between the lower arc-shaped sieve plate 17 and hammer rings. In order to change the discharging particle size, appropriate gap, may also reduce the hammer rings and sieve plate of wear and tear.
Crushing plate, sieve plate with the component is made of wear-resisting manganese steel plate, 50 mm thickness. When they are weared to 20 mm, must be replaced.
(2) Rotor.
Ring hammer coal crusher rotor and hammer type, strike back type coal crusher without too much difference except the loose connection in the structural type between hammer rings and rotating arm. Ring hammer coal crusher rotor is composed mainly by the main spindle, long diamond rotating

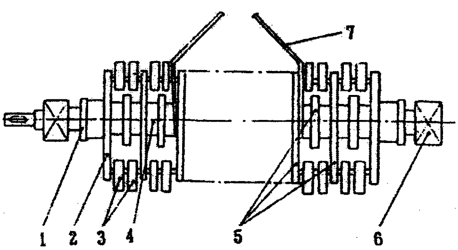

Fig. 75.3 Rotor structure
1. lock nut; *2*. garden dishes; *3*. hammer rings; *4*. spacer bush; *5*. rotating arm; *6*. rolling bearing; *7*. crane whip

arm 5, spacer bush 4, garden dish 2, hammer rings 3, rolling bearing 6 and so on. As shown in Fig. 75.3.

Turn a cross between rotating arm arrangements, rotating arm,spacer bush, garden dish and so on is installed on the main spindle by the flat key. Both ends are fixed by lock nut 1. Hammer rings are passed through between each rotating arms and garden dishes, and fixed on the both ends of the garden dish with gland bolts to limit. The installation of the hammer rings must be approved by precise counterweight to the rotor static balance to ensure that the operation of the rotor stability and reliability.

When maintenance, hoisting rotor as shown in the diagram sling 7. Motor drive rotor directly through flexible laminated coupler.

(3) Machine body, machine cover.

Machine body is welded into a lager stiffness shell with steel plate. There is feed port, dial plate, access panel, and wear-resisting protection lining etc. on the shell. Dial plate is on the center hind side of the machine body; to dial the material and the import for impurity enter into deironing room. Machine cover is installed on the right of the machine body, which is welded with steel plate. It is equipped with reflection board and deironing room. There is a deironing door on the back wall (check the window, sealed door), joining seals between it and the combination surfaces to prevent dust leakage in the runtime.

(4) The rotor is made from high quality resistant alloy material.

75.3.2 Screening Machinery

The screening mechanical sort is more. Among them, such as roller sieve, etc. thick roller sieve, fluctuation sieve, probability sieve and the other is developed in recent years. Many are used for large and medium-sized coal-fired power plant. Screening amount and screening efficiency are the key performance indicators of screening machinery. Screening amount is the productivity of screening machines which is the quality of material by screened per unit of time, in t/h. Screening efficiency is given by the screen (such as 30 mm) grain size of the following amount of material to go to the front by raw materials that are included in the following with same grain of the material content.

Screening machine's productivity depends mainly on the screen width, and screening efficiency depends mainly on the Screening length. The width of sieve surface should be fit to the feeding equipment, it cannot increase the productivity if it is so wide in the actual application. The length of the sieve surface in practical applications is usually 2.0–2.4 times the width of the sieve surface. Sieve hole size than the sieve surface area is called the effective area ratio, generally around 50–80 %. The larger the effective area is, the higher the screening efficiency is.

75.3.2.1 Principle of Operation

Take the HGS-1410 etc. thick roller screen as an example,the structure is shown in Fig. 75.4, the body of work consists of 10 parallel arrangement of the rolling sieve axis. Sieve axis by the feed side is tilt installation in order to quick separate materials, the thickness is equal after they reach the screen surface, then the screening efficiency was improved. There are many sieve trays (sheets) on sieve axis of the etc. thick roller screen, and these sieve trays are arranged with some gap between each other. The gap between sieve trays equals to sieve pore, see Fig. 75.5. Each rolling shaft is driven by a separate roller track electromotor to rotate in the same direction so as to drive materials to move ahead along the sieve surface. Sieve trays are of quincunx, and are in staggered arrangement. Several quincuncial sieve trays (sheets) are mounted on each sieve axis. The sieve trays with a special shape are used to stir and impact materials lightly. The particle size less than the gap of the sieve trays materials in the role of self weight and sieve-axis rotational force, through the roller drops to the lower discharge. The particle size larger than the gap of the sieve trays material in the sieve to continue forward movement, leaving etc. thick roller screen surface, to complete the screening process of the material.

75.4 Operation and Maintenance of Screening and Crushing Equipment

75.4.1 The Operation of the etc. Thick Roller Screen Should Pay Attention to the Following Content:

(1) Etc thick roller screen and system such as roller chain operation, start, first start roller screen, post-start belt conveyor; When stop time, belt conveyor is first, later stop roller screen, do not take the load starting. When stop must stay on the screen material discharging.

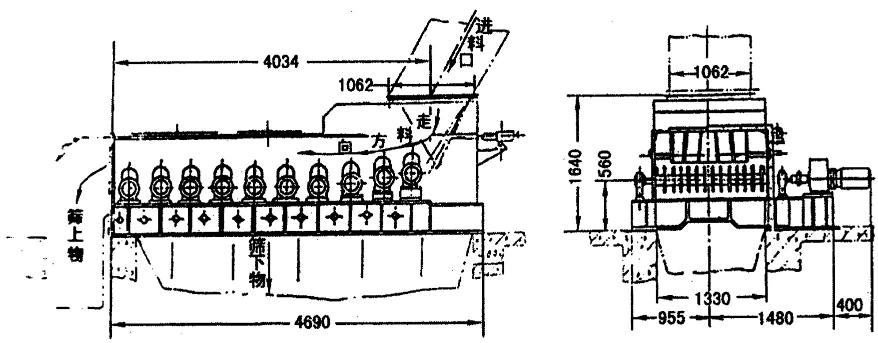

Fig. 75.4 HGS-1410 etc. thick roller screen

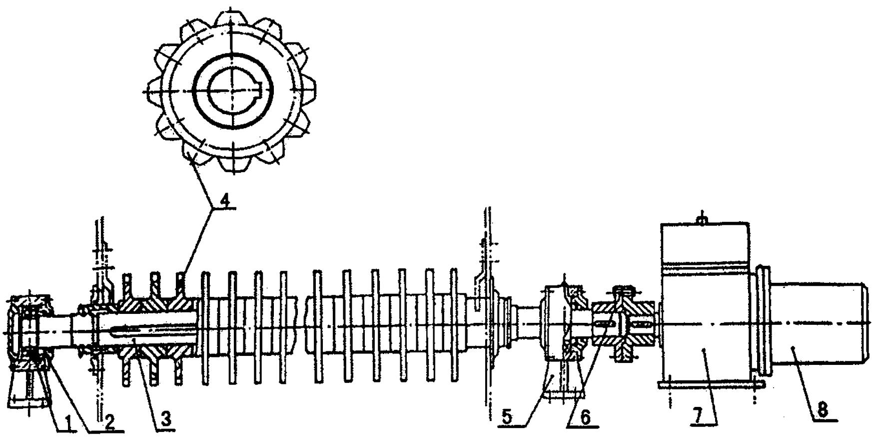

Fig. 75.5 HGS - 1410 etc. thick roller screen *1*. rolling bearing; *2*. bearing seal; *3*. sieve axis; *4*. sieve tray (sheet); *5*. bearing seat; *6*. coupling; *7*. gear box; *8*. electromotor

(2) Gare reducer all lubricating points should be timely fill lube, motor reducer inject hyperbolic gear oil, oil level can be observed through a window at the end of the gare reducer, the oil lievel in the central of oil window is advisable. Bearing of sieve axis on both sides in the bearing seat grease lubrication.
(3) Replace sieve plate, first dismantled screen axis on both sides of the screen box paddle, will of the bearing the retaining bolt to unload, then the safe coupling four cut pins to unload, take off the screen axis, replace the screen piece.
(4) When the sieve axis gets stuck for iron, wood and other impurity, between sieve machine and gare reducer is equipped with overload protection equipment. When more than allowed torque, safe coupling of cutting pin on that was cut off, screen axis stop turning.

In addition, sieve machine operation process, should pay attention to the following content monitoring:

(1) Drive motor shall be no abnormal vibration, noise and focal flavour, Shell without overheating.
(2) Gare reducer should run smoothly, no noise and no oil leakage, each place without loose connecting bolts phenomenon.
(3) The rolling bearing without heat, vibration, noise and other phenomenon, bearing body temperature not over 80 °C.
(4) Sieve axis should be flexible rotation, found that sieve axis not turn should be timely maintenance treatment, when sieve axis subjected to the impact of coal fall is not turn, should stop using.

(5) Sieve tray is not allowed in axial runout, fall off, otherwise it shall not be put into operation, to avoid sieving coal particle size does not meet the requirements.
(6) Equipment after downtime, should be timely inspection sieving, such as residues have larger size block, should keep clear of in time.

75.4.2 The Operation of Ring Hammer Coal Crusher, Pay Attention to the Following Content:

(1) The feeding should be distributed in the rotor effective length, in use often check.
(2) Coal are not allowed to mixed with larger (>150 mm), more metal, wood and impurity, surface moisture should be < 15 %.
(3) Operation of the machine often should pay attention to monitoring bearing temperature is not higher than 80 °C.
(4) Hammer rings wear to wear limit, should change in time, hammer rings weighing, distribution requirements of installation.
(5) Size of the screening plate, crushing plate thickness is 50 mm, wear more thickness than 20 mm thickness, must be replaced.
(6) The amount of wear and tear of the body wear plate not more than 2/3 of the original thickness.
(7) Need to pay attention to the operation of the machine's abnormal voice, check the fasteners, Whether there is loosening, with or without metal impact sound.
(8) Do not allow starting with load, must be in equipment to achieve normal operation speed, then applied load and put into operation.
(9) Each team should be cleaned the deironing room once time, the working conditions of inside machine parts should be checked once a week.
(10) When running, not allowed to open the access panel (insepction window, sealed door), don't affix to the machine or climbing machine, in order to avoid danger.
(11) Fixed rotor when replacing hammer rings, So that the rotor rotates dangerous.

75.4.3 The Maintenance of Ring Hammer Coal Crusher, Should Pay Attention to the Following Content

(1) Lubrication
Bearing is the important parts of the coal crusher, the mount of note oil shall be the oil chamber 1/2 ~ 2/3 advisably, often should heck the oil level of

position and oil clean dgree. You should fuel time every three months, at least cleaning twice a year, shoud replace them all and injection of new oil.

(2) Clean the deironing room
The ring hammer coal crusher can remove iron, wood and impurity in the coal. Impurity should be dialed into the deironing room, at the same time, the coal come into the deironing room, if not timely cleaning, the deironing room is full soon. So, not only can't get the effect of removing impurity, but also different impurity (such as cotton yarn, grass rope, rags etc.) is tucked in behind bars cribriform plate reseau, causing congestion. Even meet iron, because deironing room has been filled and can't accommodate, Issued with machine body percussion, cause of machine's vibration, damaged ring hammer or sieve plate grid, causing damage to the machine. So, deironing room must timely cleaning.

(3) Regulating gap of sieve plate
The ring hammer coal crusher should regularly adjust the gap beween hammer rings and sieve, the gap determines discharging size. The gap can not be too large, otherwise, not only the coal crusher can not play the normal output and efficiency, instead, will be greatly reduced the ability of exclude different impurity; Gap also cannot too small, too small gap cause the output of the equipment reducing, increasing power consumption. The adjustment of the sieve gap have a great effect on using result.

(4) The overhaul of the main parts and components (Lin 2011; Li 2011; Han 2011; Mao 2011)

① Rotor hoisting
The rotor assembly disassembly need hoisting rotor, first machine cover should open. When you are loading (removing) rotor, in the prior you should not load (or not to unload) the diale plate and fixing nuts so as to use shaft block on the machine body wall and the large and small sieve plate arc of the upper space cavity craning (or hoisting out) the rotor. oisting rope should make the rotor force equilibrium, and make the rotor self-respect deformation of minimum, when the rotor is hoisted, it can keep the rotor horizontal, seeing Fig. 75.3. Before close machine cover, in combination asbestos cord should be clip, In order to prevent the operation of dust flying out.

② Replace the sieve plate and crushing plate
Remove the cover of machine and baffle before machine body, bolts and nuts in the combination of surface. Open the machine cover. Then remove dial plate and the snap-gauge of sieve plate frame. And then, use a wire rope to jack up the assembly between the sieve plate frame and machine body, to separate the sieve plate frame from the adjusting device. Penetration of the hinge pin in the pin hole of the sieve plate frame, using the hinge pin to tie the wire rope. Removed it from the sieve plate frame upper end, Then we need to hoist the sieve plate frame, move to the front of the

machine, and hoist it out by the front of the access panel. Dismantling the sieve plate and the crushing plate without moving the rotor. After the component of the sieve have been hoist out remove the sieve plate and crushing plate, fitted with new plate.

③ Replace the hammer rings
The general rule of changing the hammer rings, the hammer rings symmetric load, install same quality hammer rings to eliminate the eccentric mass.

75.5 Conclusion

This paper describes the role of screening crushing in the system of coal conveying of the thermal power plant, and describes the etc. thick roller screen and ring hammer crusher works, indicating the correct operation and maintenance methods of the equipment, and the replacing method of the important parts in the equipment. There are some guiding significance to the stable operation of the coal conveying system and safety in production in the thermal power plant.

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Chapter 76
Quality Management System in the Application of High Purity Quartz Sand Enterprise

Li-ge Xie, Fa-cheng Yi, Zhe Wang, Yong-an Li and Huai-qing Jia

Abstract With the highly developed information technology fast, accurate and efficient consolidation of the enterprise information resources, reduce costs, improve product quality and service levels, thereby raising their core competitiveness. In view of the product procurement management, production management, quality management, took more emphasis on the analysis and research, and thus better able to manage businesses and improve the profitability of enterprises.

Keywords Data analysis · High purity quartz sand · Production working procedure · Quality management system

76.1 Introduction

In the production process of quartz sand, due to the conditions of the restrictions, a large number of data information is used manual record statistical way. The data compiled, the analysis and the processing speed is slow, and easy to cause the mistake, already could not suit the contemporary quartz sand enterprise the production development need.

Management mode and production characteristics of a quartz sand enterprises in Jiangsu Province, the use of computer networks, databases and other advanced technology to build a set of procurement, production, scheduling and management functionality in one integrated quality management system to achieve the work shop real-time data acquisition and analysis with real-time response, high stability, economic applicability and good scalability, etc. (Chen and Chen 2011). So that can improve the comprehensive competition strength of quartz sand enterprise,

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speed up the enterprise the information of the market response capacity, deal with quartz sand enterprise implementation of quality information management system.

76.2 Quartz Sand Enterprise Production Status

With the development of scientific technology, the optical power, the electronics industry, optical communication, SiO_2 thin film materials, large-scale and ultra large scale integrated circuits, lasers, aerospace, military and other high-tech industry rapid development, the growing demand for quartz sand (Jiang 2001; Zhou 2005). Special to its product purity put forward higher request. However, Look at the current domestic situation on the quartz sand industry, the production is not high and low purity. As we all know, the production of quartz sand to go through the machine, process, physical and chemical purification. So the factors affecting product quality is not only widely, but also complex.

Through a preliminary investigation and analysis on the production status of quartz sand enterprise, as well as communicate with the senior corporate leadership. To achieve the production process from raw materials to finished products, processes and storage, and other information storage and management capabilities, that can automatically generate statistical reports to provide timely product information in order to make the production process in a controlled state. And various aspects of the analysis based on data. Such as: the statistical product analysis, process capability analysis, and generate analysis charts, in order to achieve the intelligent management of the enterprise products.

76.3 Quality Management System Structure and Function

Many processes in the manufacture of quartz sand, mainly includes the process of the production data record, analysis, etc. The company for quality management system from the original stone grabbed, from the roots; Quality management system mainly from the system management and purchasing management, production process management, quality management and inventory management module of the paper analysis and research, such as Fig. 76.1. Thus better able to improve the production capacity of the enterprise and internal management.

76.3.1 System Management

Login user name and password is the first step of the system, do not have a user name and password are unable to enter the system operation. Any system that is inseparable

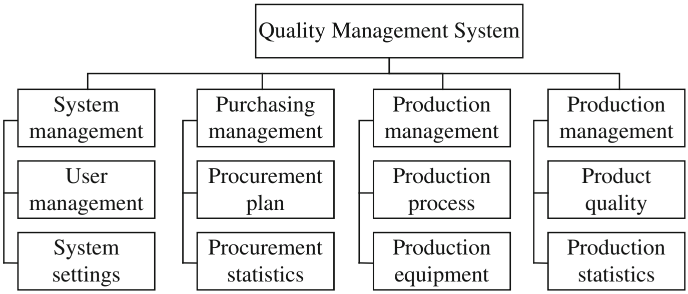

Fig. 76.1 Quality management system function diagram

from the rights management, a good rights management module, not only causes the personnel ease of operation, also for system increase luminescent spot.

In order to in this system the data security, the personnel responsibility, assigns the different permissions, which are the system most basic functions. System administrators have distribution user permissions and management enterprise resources function, and the user is responsible for the corresponding obligations are based on their responsibilities and powers (Oh and Park 2003; Guo and Liu 2006).

76.3.2 Purchasing Management

A comprehensive record of procurement information, through centralized procurement interface can view the purchase requisitions, purchase orders, order management, warehousing and other information. Enable managers to a full range of control and tracking, Enterprise purchase management to achieve perfection.

This enterprise needs to purchase large quantities of original stone, acid, alkali, coal, equipment components and so on. Purchasing these items, the first is based on the reported production sector production schedule needs, the Department needs to plan summary, and then by the Production vice president or General Manager, and the approval of leaders, after approval by the applications processed by the procurement department. If the administrative personnel the discovery goods stock insufficiency, and to prevent the influence enterprise to produce, you can promptly notify the purchasing department for procurement. Purchasing department personnel can directly fill in the application form, to the higher-level approval. If approved, Procurement staff should direct procurement and storage.

In the procurement process, not only to record the purchase of products category, quantity, unit price, the department, the approval (Yes, No) among others, at the same time you can also record the vendor’s information, to cooperate in the future can select suitable suppliers, access to the highest quality goods at the lowest cost. Eliminate unqualified suppliers, development potential, continuous innovation, establishes a long-term stable supplier relationship (Trent and Monczka 1998; Carr and Smeltzer 1999).

76.3.3 Production Management

The module mainly includes the production craft management and the production equipment management. Quartz sand production technique is: Crush, magnetic separation, scrubbing, and acid leaching, Calcimine water quenching, flotation, drying and so on the processes. In the quartz sand production process affects the factor to be multitudinous, in order to further improve the purity of quartz sand quality, the company has constantly adjust production processes and device management.

In accordance with the needs of production, the system can on-demand operations and automatically generated routes, and the production line independently generate the form. According to the actual need to develop an objective, reasonable and precise production process, abandoned the traditional single production process. From the interface you can see that the products of the basic information section such as: material Abnormal, materials, Yield, Waste ore (the check all the information access and check range by access control. Picking from the upper section; Raw materials are measured in Kg) and so on, Carrying on the Omnidirectional production track management (Sumner 2000; Wu 2006; Li et al. 2004; Fan and Wu 2001; Shegalov et al. 2001).

Device management is to manage the production process primarily used in machinery and equipment, such as crushers, Magnetic separator machine, flotation machine, etc. The module is mainly statistical production device specific information, such as: daily operations, damage, and preventive maintenance. According to the production progress and the equipment situation record, the priority which uses according to the production in determined services the worker to carry on the service. Thus forming a simple equipment maintenance report, status report, spare parts inventory reports, and so on.

76.3.4 Product Management

Quality quartz sand at the international level there is no set standard. United States of UNIMIN Corporation is the world's largest supplier of quartz sands the product quality standards are widely recognized as the industry standard. Most of the domestic enterprise according to the enterprise quality standards for reference, combined with the company's production situation and customer needs of production, as far as possible to produce low impurity quartz sand (Le et al. 2004; Foster et al. 2001; Cheng 1997; Miao et al. 2005).

Product management is primarily responsible for the management of products to add and update, and query all product information. Examines the product in a page the basic information, sales, inventory and so on (the check all the information access and check range by access control). Most important thing is to search and statistic analysis of the product; Depending on the batch number product level information such as product can be retrieved. Statistical analysis can be the result of bar charts, line charts, pie charts show that comparison years, months, weeks, days, and can be exported and printed.

Use the ICP testing finished products to determine grade and storage (including returns); while sales to build out a library form. By computers can periodically counting inventory on a regular basis, balance inventory. Queries can be based on a variety of criteria when combining query records of goods, export to Excel table data, and you can print out a list of data.

76.4 Key Technologies

The system is based on the Windows operating systems, using the C# language in the Visual Studio 2005 developing front desk user interface, back-end database using Microsoft SQL Server 2008. The minimum requirements for CPU hardware configuration: the P4 1500 Hz RAM: 256 MB HDD: 40 GB. The system of the key techniques is to:

76.4.1 Workflow Process

Flow processing need to analyze had the flow rationality, and proposes the more highly effective processing plan. This is round-trip treating processes, its quality direct influence system validity.

76.4.2 Security Control

System contains some internal data of the enterprise to ensure that this data is not stolen and the destruction is the primary task of the system. In terms of protecting internal data security, developed a set of solutions (including backups, database permissions, log back in, and so on) to ensure data integrity, independence and security of the system.

76.5 Conclusion

The system reflects the rationality of the system architecture design, interface clear in appearance, in line with the actual situation and characteristics; I believe that accompanied by the smooth implementation of the quality management system of product, purity and quality quartz sand enterprises resource management will be further enhanced. In the implementation process of quality management system, will encounter some problems, but as long as an objective analysis of the source of the problem set to the enterprise responsible attitude, trying to eliminate the interference factors for purity of quartz sand, improve product quality and profit margins.

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Chapter 77
Real Estate Project Quality Control Mechanism Based on Stackelberg Game

Fei Xu and Hong Ren

Abstract This paper attempts to analyze the game playing in the quality control of two-level supply chain that consists of real estate developers and project contractors, based on the thinking of differential game. The Stackelberg game, in which developers are leaders of supply chain and contractors are followers, is employed to study optimal behavior selection of both parts under the quality control situations of cooperative game and non-cooperative game. It finds that, in the quality control of two-level supply chain that consists of real estate developers and project contractors, the game structure of cooperative quality control is better than that of non-cooperative quality control.

Keywords Real estate project · Quality control · Game playing · Supply environment

77.1 Introduction

Following the trend of keen market competition, the competition confronted by real estate developing enterprises is not the competition among them, but among supply chains constituted by many enterprises. The traditional quality control theory must be updated to the theory of condition of the supply chain to fit for the market needs. Under the new supply environment, real estate project quality is affected by the all enterprises in supply chain. Although internet and telecommunication provides technical basis for cooperation among enterprises, the communication and coordination among enterprises in a supply chain are still very difficult due to constraint of space and time. Therefore, it is important to develop a

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cooperated quality control mechanism, which forces enterprises in a supply chain cooperating to reaching Win–Win situation (He and Liu 2004).

Many scholars at home and abroad, by using the game theory, studied supply chain quality through contract coordination. Many scholars such as Saad et al. (2002) examine the early progress towards the adoption of supply chain management (SCM) relationships in construction.

Hung et al. (2011) noted that information sharing has been an important research issue in supply chain management. Wadhwa et al. (2010) explores the effect of information transparency and cooperation among the front nodes of supply chains. Vrijhoef and Koskela (2000) argued that due to construction peculiarities, supply chain management has four specific roles in construction. Hong and Chen (2001) using the Contrast Theory, designed effective excitation mechanism to make contractors to improve product quality, and clarified the necessity of eliminating asymmetric information of product quality. Khalfan et al. (2001) discusses CE and its application to the construction, reviews and compares the existing tools and methods for CE readiness assessment, discusses supply chains generally and construction supply chain specifically, and stresses the need to assess the readiness of the construction supply chain for the adoption of CE. They also present a new readiness assessment model for the construction industry supply chain, and gives examples of its use to assess construction organizations. Dubois et al. (2004) analyze interdependence existing both within and among supply chains. They conclude that supply chains need to be analyzed in their contexts, and that this has consequences for recommendations concerning the organizing and management of them. Saad et al. (2002) examines the early progress towards the adoption of supply chain management (SCM) relationships in construction. Akintoye et al. (2000) study UK construction supply chain, they research appears that construction supply chain management (SCM) is still at its infancy but some awareness of the philosophy is evident, contractors identified improved production planning and purchasing as key targets for the application of SCM in construction, found that barriers to SCM in construction success included: workplace culture, lack of senior management commitment, inappropriate support structures and a lack of knowledge of SCM philosophy. Training and education at all levels in the industry are necessary to overcome these barriers.

Huang and Lu (2003) studied the adverse selection in supply chain quality management under asymmetric information. Zhou et al. (2006) investigated the impacts of contract design on contractors' quality precaution decision and real estate developers' quality test in the supply chain quality management process. Stanley et al. (2001) examine the relationship between product architecture, supply-chain performance metrics, and supply-chain efficiency. They model the contracting relationship between a supplier and a buyer. George (2000) considers the potential of applying SCM to integrate the construction process in Singapore, and thereby, address its pressing problems including its poor environmental performance. It is found that SCM can help to green the construction supply chain in Singapore. Some recommendations on how awareness of SCM can be enhanced, and its application by construction enterprises made most likely to succeed are offered. Edum-Fotwe et al. (2001) presents a survey on the practices associated with the acquisition, use, storage and transfer of information by a sample of professionals (actors) within the construction supply chain, and presents results from a survey that looks at some aspects of how key actors in the construction supply chain address these information-related issues. Anthony et al. (2005) study point out that many enterprises are dependent on other small sized firms to provide products quality. Geoffrey et al. (2001) examines the skills requirements necessary for effective supply chain partnerships in the UK construction industry.

Based on the review of relevant literature, it finds that these research works analyzed the quality control in supply chain from the stable perspective. In view of the complexity and instability of quality control, it is more practical to investigate the quality control of supply chain under a dynamic framework. Therefore, this paper, studies the strategy of quality control for developers and contractors in two-level supply chain under the situations of cooperation and non-cooperation. It attempts to establish a cooperated quality control mechanism in supply chain to achieve the improvement of efficiency in supply chain management.

77.2 Methodology

77.2.1 Assumption of Model

This paper assumes a two-level supply chain constituted by a developer (D) and a contractor (S). The contractor provides raw materials, equipments and other things to developer. The developer integrates all things, packs and sells to buyers, which is the core enterprises in this supply chain. In the quality control of supply chain, real estate developer is responsible for overall quality control and contractor is responsible for the quality control of materials, techniques and equipments. It assumes that

(a) contractor and developer are both risk neutral, and regard profit maximization of supply chain system as the first principle.
(b) The profit from cooperative quality control is only assigned between developer and contractor. The developer, as the core enterprise in supply chain, decide the profit share π of contractor, $\pi \in (0, 1)$ is a constant and set in advance. In the meanwhile, developer acquires the remaining profit share $1 - \pi$.
(c) The project quality is decided by the quality control degree of developer and contractor. It is a dynamic process and expressed by Eq. (77.1)

$$Q(t) = \alpha \mathrm{E}_d \times \beta E_s - \gamma Q(t) + Q_a \tag{77.1}$$

$Q(t)$ indicates the acceptance rate of project quality at the time of t (100 means that 100 % of projects reach the standard). γ is relative attenuation rate of quality equation when there is no quality control. E_d indicates the efforts of real estate developer on project overall quality control, which is expressed by the equation $E_d = a_1Q + a_2$, a_1, a_2 are both constants. E_s indicates the efforts of contractor on quality control of raw materials, equipment and other services. In view of the features of effort cost equation of, the effort cost equations of developer and contractor are expressed as $C(E_d) = \mu_d E_d^2/2$, $C(E_S) = \mu_s E_s^2/2$, μ_d and μ_s indicate the influence coefficients of different effort cost.

(d) There is in direction proportion between project quality and benefit caused by improvement of project quality, then

$$U(Q) = \varphi + \eta[\alpha \mathrm{E}_d \times \beta E_s - \gamma Q + Q_a] \quad (77.2)$$

where φ is a constant, η is the influence coefficient of project quality on income equation.

(e) $V_d(Q_0)$, $V_s(Q_0)$ and $V_T(Q_0)$ indicate the maximum profit of developer, contractor and the whole supply chain in infinite time zone. c_1, c_2, k_1, k_2 are all constants.

$$\begin{aligned} V_s(Q) &= k_1Q + k_2 \\ V_d(Q) &= c_1Q + c_2 \end{aligned} \quad (77.3)$$

77.2.2 Non-cooperative Game Playing Model of Quality Control

Under the condition of non-cooperative quality control, developer plays a role of leader in quality control of supply chain, and contractor is the follower of quality control. This is Stackelberg game playing between developer and contractor. Developer, as the leader of game playing, decides their own efforts on quality control and subsidy proportion r for the effort cost of contractor's quality control. Contractor decides their own efforts on quality control based on the decision of developer. The best game playing strategy is Static feedback Stackelberg equilibrium strategy. Referring to Ref. (Akintoye 2000), the best value function $V_s(Q)$ can be expressed as:

$$\begin{aligned} \rho V_s(Q) = \max_{E_s}\{&\pi[\varphi + \eta[\alpha \mathrm{E}_d \times \beta E_s - \gamma Q + Q_a]] \\ &- \frac{\mu_s}{2}(1 - r)E_s^2 + V_s'(Q)(\alpha E_d + \beta E_s - \gamma Q)\Big\} \end{aligned} \quad (77.4)$$

This is HJB equation, and the first-order condition to reach maximization is $E_s = \frac{2\beta V_s'(Q)}{(1-r)\mu_s}$. Likewise, developer decides their best strategy according to rational responses of contractor to reach maximum profit, because developer knows that contractor will take the best strategy based on the efforts of developer on quality control. Thus, the best value function of developer is

$$\rho V_d(Q) = \max_{E_d}\{(1-\pi)(\varphi + \eta[\alpha \mathrm{E}_d \times \beta E_s - \gamma Q(t) + Q_a]) \\ -\frac{\mu_d}{2}E_d^2 - \frac{\mu_s}{2} r E_s^2 + V_d'(Q)(\alpha E_d + \beta E_s - \gamma Q)\Big\} \tag{77.5}$$

Combining the above equation together, the first-order conditions to reach maximization are $Ed = 2\alpha \frac{V_s'(Q)}{\mu_d}$, $r = \frac{2V_d'(Q) - V_s'(Q)}{2V_d'(Q) + V_s'(Q)}$. Putting these equations into Eq. (77.5), it can be got that:

$$\rho V_d(Q) = \left[(1-\pi)\eta - \gamma V_d'(Q)\right]Q + (1-\pi)\varphi \\ + \frac{\left[\alpha V_d'(Q)\right]^2}{2\mu_d} + \frac{\left[2V_d'(Q) - V_s'(Q)\right]^2\left[\alpha V_d'(Q)\right]^2\beta^2}{4\mu_s} \tag{77.6}$$

$$\rho V_d(Q) = \left[\pi\eta - \gamma V_s'(Q)\right]Q + \pi\varphi \\ + \frac{\alpha^2 V_d'(Q)V_s'(Q)}{2\mu_d} + \frac{V_s'(Q)\left[2V_d'(Q) + V_s'(Q)\right]\beta^2}{4\mu_s} \tag{77.7}$$

Therefore, the static feedback Stackelberg equilibriums under the condition of non-cooperative game playing of quality control are

$$E_{dn} = 2\frac{(1-\pi)\alpha\eta}{(\rho+\gamma)\mu_d} \tag{77.8}$$

$$E_{sn} = \frac{(2-\pi)\beta\eta}{(\rho+\gamma)\mu_s} \tag{77.9}$$

The optimal value functions of developer and contractor are

$$V_{dn} = (1-\pi)\eta Q/(\rho+\gamma) + \frac{(1-\pi)\varphi}{\rho} \\ + 2\times\frac{\eta^2}{(\rho+\gamma)^2\rho}\left[\frac{(1-\pi)^2\alpha^2}{2\mu_d} + \frac{(2-\pi)^2\beta^2}{4\mu_s}\right] \tag{77.10}$$

$$V_{sn} = \frac{\pi\eta Q}{\rho+\gamma} + \frac{\pi\varphi}{\rho} + 2\frac{\eta^2}{(\rho+\gamma)^2\rho}\left[\frac{\pi(1-\pi)\eta^2}{\mu_d} + \frac{\pi(2-\pi)\beta^2}{2\mu_s}\right] \tag{77.11}$$

The optimal value functions of whole supply chain is

$$V_{Tn} = \frac{\eta Q}{\rho+\gamma} + \frac{\varphi}{\rho} + 2\frac{\eta^2}{(\rho+\gamma)^2\rho}\left[\frac{(0.51 - 0.49\pi^2)\alpha^2}{\mu_d} + \frac{(0.51 - 0.124\pi^2)\beta^2}{\mu_s}\right] \tag{77.12}$$

77.2.3 Cooperative Game Playing of Quality Control

Under the condition of cooperative game playing between developer and contractor on quality control, the both parts, regarding the best profit of supply chain as the first principle, decide the value of Ed and Es together. Then, the best profit function V(Q) is

$$\rho V_s(Q) = \max_{E_d, E_s}\left\{\varphi + \eta Q(t) - \frac{\mu_d}{2}E_d^2 - \frac{\mu_s}{2}E_s^2 + V'(Q)(\alpha E_d + \beta E_s - \gamma Q)\right\} \tag{77.13}$$

By maximizing the right part of Eq. (77.13) to get a_1 and a_2, then, putting them in the Eq. (77.13):

$$\rho V(Q) = (\eta - \gamma V')Q + \varphi + \frac{(\alpha V')^2}{2\mu_d} + \frac{(\beta V')^2}{2\mu_s} \tag{77.14}$$

According to the Eq. (77.14), linear optimal value function of Q is the solution of Eq. (77.13). Putting E_d and its derivative to Q into Eq. (77.14):

$$\rho(a_1 Q + a_2) = (\eta - \gamma a_1)Q + \varphi + \frac{\alpha^2 a_1^2}{2\mu_d} + \frac{\beta^2 a_1^2}{2\mu_s} \tag{77.15}$$

The optimal value function coefficient a_1 and a_2 are gotten from Eq. (77.15), and the optimal quality control efforts of developer E_{dw} and contractor E_{sw} are $E_{dw} = \frac{\eta\alpha}{(\rho+\gamma)\mu_d}$ and $E_{sw} = \frac{\eta\beta}{(\rho+\gamma)\mu_s}$. Thus, the optimal value function of whole real estate supply chain is

$$V_{tw} = \frac{\eta Q}{\rho + \gamma} + \frac{\varphi}{\rho} + 2\frac{\eta^2}{(\rho+\gamma)^2\rho}\left(\frac{0.51\alpha^2}{\mu_d} + \frac{0.51\beta^2}{\mu_s}\right). \tag{77.16}$$

77.3 Results

The equilibrium outcomes between developer and contractor are as:

From Table 77.1, it finds that (1) the efforts of developer on overall quality control under the situation of cooperative game playing are more than that under the situation of non-cooperative game playing; (2) the efforts of contractor on quality control of raw materials under the situation of cooperative game playing are more than that under the situation of non-cooperative game playing.

At the same time, it can be deduced according to Table 77.1.

From Table 77.2, we can find that the overall profit of supply chain under the situation of cooperative game playing on quality control is more than that under the situation of non-cooperative game playing on quality control. Based on the

Table 77.1 The coparison of non-cooperative and cooperative game playing on quality control between developer and contractor

	N	**W**	**N–W**
Contractor	Esn	Esw	<0
Developer	Edn	Edw	<0

Note N which means non-cooperative game playing, W which means cooperative game playing

Table 77.2 Comparison of optimal overall profit in quality control of non-cooperative and cooperative game playing between developer and contractor

	N	W	△
Contractor	Vsn	Vsw	
Developer	Vdn	Vdw	
Vtn	Vsn + Vdn		
Vtw		Vsw + Vdw	<0

Note N which means non-cooperative game playing, W which means cooperative game playing Whereas △ = Vtn − Vtw

Table 77.3 Pareto optimality strategy and condition accepted by developer and contractor

	N	W	△	N–W
Contractor	Vsn	Vsw		<0
Developer	Vdn	Vdw		<0
Vtn	Vsn + Vdn			
Vtw		Vsw + Vdw	<0	

Note N means non-cooperative game playing, W means cooperative game playing
△ = Vtn − Vtw

assumption of economic man, not all best strategies are accepted by developer and contractor when conducting cooperative quality control, as developer and contractor may acquire less profit in cooperative situation. Therefore, Pareto optimality strategy accepted by both developer and contractor should meet the following constraints (Table 77.3).

In addition, the profit proportions ΔV of developer and contractor depend on social average profit level and negotiation between them.

77.4 Discussion

The efforts and profits of optimal quality control depend on the selection of parameter. Assume that $\rho = 0.11$, $\pi = 0.12$, $\eta = 0.3$, $\varphi = 10$, $\mu_d = 0.22$, $\mu_s = 0.2$, $\alpha = 2.5$, $\beta = 1.5$, $\gamma = 0.3$, $Q_0 = 80$, the overall profits of supply chain under the situations of non-cooperative and cooperative game playing are shown in Fig. 77.1.

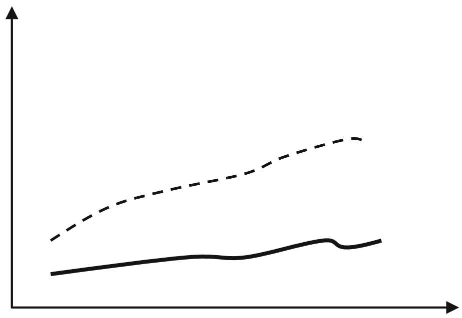

Fig. 77.1 Comparison of overall profit of supply chain in the situations of cooperative and non-cooperative quality control (*Note Solid* and *dashes* represent profit transformation in the situations of cooperative and non-cooperative quality control

It can be seen from Fig. 77.1, the overall profit increases rapidly in the situation of cooperative game playing on quality control, and it increase slowly in the situation of non-cooperative game playing on quality control. Also, the overall profit in the in the situation of cooperative game playing between developer and contractor on quality control is more than that in situation of non-cooperative game playing. That is to say, cooperative quality control is better than non-cooperative quality control, which is in accordance with mathematic derivation.

77.5 Conclusion

This paper studies the dynamic coordination of quality control in the two-level supply chain that consists of developer and contractor, based on the differential game method. It analyzes the Stackelberg game, in which developers are leaders of supply chain and contractors are followers, and discuss the optimal behavior selection of both parts under the quality control situations of cooperative game and non-cooperative game. Through the comparison of game playing equilibrium outcomes, the efforts of both parts on quality control in the situation of cooperative game playing are more than that in the situation of non-cooperative game playing. Moreover, the profit of supply chain in the situation of cooperative quality control is more than that in the situation of non-cooperative quality control. For developers and contractors, game playing structure of cooperative quality control is better than that of non-cooperative quality control.

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Chapter 78
Research on Quality Inspection and Reliability for the Loudspeaker of a Voice Box

Zhao Zhan and Qi-yong Zeng

Abstract The loudspeaker is one of the most important parts of a voice box. The quality of the loudspeaker has a direct impact on the whole quality of the voice box. The main works are focused on the study of the quality inspection methods and how to improve the reliability of the loudspeaker. The quality inspection scheme of the loudspeaker has been worked out. The Failure mode and effect of the loudspeakers of the American motivity DB118 type voice boxes have been analyzed by one of the quality tools FMEA. The key factors which affect the reliability of the loudspeaker have been found out. Corresponding improvement suggestions were put forward after analyzing these factors and the purpose of improving the reliability of the loudspeaker can be achieved.

Keywords FMEA · Loudspeaker · Optimization of reliability · Quality Inspection

78.1 Introduction

The loudspeakers have been widely used in many fields of human activity since they appeared in 1925. The competition in the loudspeaker market is also particularly intense. The manufactures must keep on improving their technology, making innovation, strengthening the quality management of the product, and increasing the productivity so that they can survive and develop in this competitive environment and make great economic benefits. Therefore it is very important for the manufactures to design an applicable inspection plan. In addition, the

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reliability of the loudspeaker is the satisfaction degree standard for the users to estimate. It is also an important characteristic of high-grade loudspeaker products. It is required us to pay attention to the reliability design of the loudspeakers (Zhang 2009; Wang 2007).

In the research on the reliability of the loudspeaker, failure control has been the focus of attention of the engineers. The general idea of failure control is design verification, design review and relevant experiments, then to find out the problems and solve them. But when the customer has high requests about the product performance and development speed, the weaknesses of this way is exposed such as development repeatedly, cycle extended, high rejection. So this way of failure control should be adjusted (Wang and Hu 2006; Hu and Cai 2006).

Failure Mode and Effect Analysis (FMEA) is one of the five quality improving tools. It was used to the reliability analysis and improvement of the loudspeaker. By using FMEA, the failure modes in products and its process can be effectively identified. The failure can be prevented and effective correction plan can be provided in time to analyze and improve the reliability of the loudspeakers.

78.2 Quality Inspection of Loudspeakers

The loudspeaker's structure is simple. It consists of the magnetic circuit system, vibration system and some other affiliate structures. But there are two kinds of energy conversion. The electricity energy is transferred to the vibration energy and then to the sound energy in this simple structure. The loudspeaker involves complicated characteristic indexes. Some important quality characteristic indexes and their inspection methods are listed in the following aspects (Yiannis et al. 2011).

78.2.1 Quality Characteristic Indexes of the Loudspeaker

Although the loudspeaker's structure is simple, it involves many complicated characteristic indexes which are the loudspeaker impedance, the total quality function, equivalent air volume, the input voltage, input power, frequency characteristics, the sound pressure level in free field and semi-free field, frequency response, sound output power, the directionality, amplitude nonlinear, and leakage magnetic (Zhang 2009; Wang 2007; Lin 2011). In practical production, the product cannot be tested one by one, item by item because of the testing cost. And some quality characteristic indexes, such as the leakage magnetic and so on, are not proper for the loudspeakers used in voice box. So it is necessary to choose important quality characteristic indexes for inspection reasonably in order to raise the speed of production efficiency and optimize the production line of the process capability. The following characteristics indexes of loudspeakers are chosen for quality inspection generally.

78.2.2 Pure Tone Audiometry

Pure Tone Audiometry is to feed the loudspeaker a sine signal with assigned voltage and a range of frequencies, which are used to check the assembly quality of the loudspeaker. General inspection method is to feed the loudspeaker a sine signal whose electrical power is half of its nominal electrical power. The pure tone is checked in the place 0.3 m far from the loudspeaker. There should not be reflecting objects within this distance. No extra acoustic loads are added to the loudspeaker unit.

78.2.3 Impedance and Impedance Curve Measurement

The nominated impedance of the loudspeaker is a pure resistance value specified by manufacturers. This pure resistance is used to replace the loudspeaker when determining the effective electrical power of a source signal. It is shown as a minimum value which follows the first maximum value. As the impedance curve is the function that expresses the impedance to frequency. Constant-voltage method or constant-current method are often used to measure the impedance curve. The constant-current method has priority. Small enough voltage or current values are chosen in measuring the impedance curve with the scope of frequency from 20 Hz to 20 kHz or a larger scope of frequency. The measurement should be in normal measuring conditions. The results should be expressed as frequency function curve. The voltage and current values should be noted in the report.

78.2.4 Frequency Response and Frequency Response Curve Inspection

Frequency response reflects the main range of working frequency of the loudspeakers. When a signal source with a constant voltage is fed to the loudspeakers which are in a free field or a semi-free field, and the frequency of the signal source varies from low to high, the sound pressure level will change as the frequency changing. Frequency response is usually recorded as a sound pressure-frequency curve. After a long-term observation and experience accumulation, it is found that a better loudspeaker with good sound quality usually has evener axial frequency response curve. So the sound quality of the loudspeaker can be judged through this way.

LMS software can be used to draw the frequency response curve in the actual production test. The advantages of this drawing method are simple to operate, and the accuracy is high and so on. The LMS test software has a wide range of applications in the production of the loudspeaker.

78.2.5 Package, Dimensions and Assembly Inspection

The main requirement of packing of the loudspeaker is that the packing information should be complete. The products packing can protect the loudspeaker so that it will not be damaged and damped. The outer packing will not be deformed or damaged. Then it can be received.

Generally it's not necessary to measure the dimensions by a caliper except that the drawing is given. The size should be within the tolerance range. If the drawing has no key controlling dimensions, the production can be judged by actual assembly process.

It is usually to try to assemble the loudspeaker when assembly inspection. If the loudspeaker is not different to assembled or the assemble is not too tight or too loose, then it can be accepted.

The most parts of the loudspeaker are always inspected by sensory method. The other parts of the loudspeaker can be inspected and judged by instruments. The operation is simple and convenient. The inspection can be done online in the manufacturing process, and can guarantee the quality of the loudspeakers better.

78.3 Analysis and Improvement of the Reliability of the Loudspeaker

The reliability of the loudspeaker has become an important factor which must be considered by the designer when they are designing a loudspeaker. But the traditional method of failure control has many shortcomings such as product development repeatedly, cycle extended, high rejects and so on. In this article, Failure Mode and Effect Analysis (FMEA) is used to analyze and improve the reliability of the loudspeaker.

78.3.1 FMEA of the Loudspeaker

FMEA is widely used in the design of the product and process development (Seung and Kosuke 2003; Korayem and Iravani 2008). It is an important tool for quality analysis. It can help prevent high price failure. It provides an effective way that is expected and can eliminate failure. It is a kind of analysis and prevention tool which is used to identify the product or process failure (before the failure occurred). FMEA can provide us the way to deal with failure, then we can take appropriate corrective action. In this article this method of FMEA was tried to be used to do the failure control of loudspeakers, in order to analyze all possible range of failure modes and their reasons, and then find the solutions.

The FMEA results of the loudspeaker are to establish a FMEA table. Sort all kinds of failure modes by their risk priority number (RPN) values. The establishment of FMEA table can make the loudspeaker engineers who are engaged in product design and process design thinking actively, clearly and methodically. The RPN of FMEA table should be always updating, because this process is also the process of accumulating wisdom and experience of the loudspeaker engineering team (Li and Hu 2005).

The Process Failure Mode and Effect Analysis table of the Motivity DB118 type loudspeaker is shown in Table 78.1.

After sorting the RPN, it is concluded that the serious problems which have high risk priority, whose RPN values are over 100, are the voice coil burned, foreign objects drop into the vibration system and the quality problem of glue and the noise because of those failures.

78.3.2 Improvement of the Reliability of the Loudspeaker

(1) *Voice coil burned*: The voice coil is the heart of the loudspeaker. The vast majority failure modes of the loudspeaker are due to the damage of the voice coil besides some mechanical damage. Based on the past experience, Over 80 % of the loudspeakers are breakdown because of the damage of its voice coil.

One reason of voice coil burned is that the heat cannot dissipate very well. The conduction board and the conduction column can be punched to strengthen the heat conduction to solve this problem. The color of the voice coil skeleton can be designed into dark. The conduction board and conduction column can also be roasted to black. Black radiation materials were coated onto outer parts of the voice coil windings to increase the heat absorption coefficient. All of the above methods help for heat conduction.

Another case is that voice coil is burned because of short circuit, which is generally caused by the problem of enameled wire. Good solving methods are to use enameled wire with good heat resistance and good abrasion resistance. And attention should be paid to do processing strictly according to the process requirements to ensure that the voice coil has high reliability level (Korayem and Iravani 2008).

(2) *The voice coil scraped*: The voice coil will be scraped when the voice coil is placed in a wrong position, or the voice coil becomes deformed, or the magnetic gap is partially crooked. Some foreign objects dropping into the magnetic gap can also produce noise.

Centering disk is used to keep the voice coil in the right place of the magnetic gap, and to prevent foreign body dropping into the magnetic gap, so that the voice coil can be protected. A high quality centering disk can ensure that the gap is clean and ensure the voice coil can only make axial vibration, without radial vibration that makes the voice coil rubbing with the magnetic gap wall and make noise.

Table 78.1 Process failure analysis mode of the loudspeaker system for voice boxes

Serial No.	Failure	Potential failure reason	Potential failure effects	Fail rate	Severity degrees	Frequency degrees	Design control	Detection degrees	RPN	Final effect
1.	Vibration system	The voice coil's heat radiation is not good or the voice coil short circuit	Voice coil burned	3/5	8	10	Observed directly, or using multimeter to test the short circuit	2	160	No sound, cannot complete electro-acoustic conversion
		Foreign drop into the vibration system	The voice coil scraped	1/3	6	9	Add test signals, subjective judgment	6	324	Noise appeared while loudspeaker working
		The glue cannot resistant the heat well, sticky is not good	The voice coil scraped	1/3	7	9	Observed directly	2	126	Serious noise appeared while loudspeaker working
		The paper cone material shortage of toughness, add the low frequency of the high power	The paper cone rupture	1/2000	5	4	Observed directly	1	20	Small noise appeared while working
2.	Magnetic circuit system	The glue used for magnets cannot resistant heat well and the sticky is not good	Magnets fall off	1/200000	8	1	Observed directly	1	8	No sound, cannot complete electro-acoustic conversion
3.	Lead wire	Lead wire's length is insufficient, toughness is not strong	More shares lead wire break	1/2000	8	4	Multimeter detection the open circuit part	1	32	No sound, cannot complete electro-acoustic conversion
		Welding process inadequate	Empty welding appears, lead to open circuit	1/200000	8	1	Multimeter detect the both sides of the solder joints	8	64	No sound, cannot complete electro-acoustic conversion
4.	Appearance	Processing, storage process not perfect	Mechanical damage, lacquer layer falls off	1/10000	2	3	Observed directly	1	6	Appearance does not conform to the requirements, but seldom found defects
		Packaging process responsibility consciousness is not strong, packaging process not perfect	The sign is not clear, trademark does not stick firm	1/5000	2	3	Observed directly	1	6	Appearance does not conform to the requirements, but seldom found defects
			Packing mistake	1/100000	6	1	Observed directly	1	6	Customer not satisfied
			Product short-shipped	1/200000	7	1	Observed directly	1	7	Customer not satisfied
			Packing does not meet the technical requirements	1/3000	2	4	Observed directly	1	8	Appearance does not conform to the requirements, rarely found defects

In addition, the magnetic gap needs dustproof, so dust sponge or dustproof nets should be mounted in the hole. It can not only ensure the heat conduction, but also can protect the voice coil from the dust.

(3) *Adhesive failure of the vibration system*: Adhesive failure phenomenon always appears because of the weak viscosity or heat resistance of the glue. The adhesive failure of the vibration film is often due to insufficient sticky force. Meanwhile, the adhesive failure of the centering disk is always due to the heat resistance problem.

Nowadays most of the glue of domestic production is worse than those produced in foreign countries. While choosing the high quality glue will increase costs. Thus it is very important to increase domestic adhesive heat resistance, mechanical and environmental protection. It is an important research direction to develop kind of high quality glue even better than the foreign production (Wang 2006).

78.4 Conclusion

The relevant knowledge about the quality inspection and reliability engineering are used to the loudspeaker of the Motivity DB118 type of voice box. It is concluded that:

(1) The quality characteristic indexes of the loudspeaker are analyzed. And the methods of quality inspection for the key quality characteristics indexes are designed.
(2) The Failure Modes and Effects Analysis tool was used to analyze the failure mode of the loudspeaker of DB118 voice box. It is found that the key reasons which affect the reliability are the voice coil burned, the foreign objects drop into the vibration system and the adhesive failure of the vibration system.
(3) Some corresponding improvement suggestions were put forward, such as to punch thermal holes, to deepen a voice coil skeleton color, or to use excellent quality centering disk, to add dustproof nets, and to use high quality glue, finally to achieve the goal that is to optimize the reliability of the loudspeakers.

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Chapter 79
Research on the Capacity Fluctuation Analysis of Compressor Blade Production Line

Bing Chen, Kai Liu and Ze-bing Fan

Abstract The aero-engine compressor blade production line capacity fluctuation problem is studied in the paper. A model of capacity fluctuation control has been established. Nonconforming rate control chart and capacity fluctuation control chart based on similar process have been designed. A method to calculate process capacity index and production capacity evaluation index is proposed. Pattern recognition for capacity fluctuation based on SRFM network is researched and related mathematic model is built. In the end, a case is analyzed to verify right of method above mentioned.

Keywords Capacity fluctuation model · Fluctuation analysis · Pattern recognition · Production capacity evaluation index

79.1 Introduction

Compressor blade is one of the core parts of aero-engine. It has complex wall-thin structure, strict technical requirement, and long manufacturing cycle. The mode of Multi-varieties and Small-batch Production is often adopted in the production line of compressor blade. There are a lot of uncertainty factors that can influence the stable running of production line. Compressor blade production line become a

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complex system with different factor interaction each other. A small fluctuation caused by some change of factor may influence the capacity of production line. How to control production capacity in the complex system becomes a difficult and hot field.

The production capacity is the volume of products that can be generated by a certain production organization and the technical level in a given period by using current resources. Research on the production capacity included capacity evaluation, capacity scheduling optimization, capacity bottleneck identification and capacity planning and management. The bottleneck identification is key and base for capacity evaluation.

Li proposed a method for predicting the throughput bottlenecks of a production line using autoregressive moving average (ARMA) model. The production blockage and starvation times of each station was considered to be a time series used to predict throughput bottlenecks (Li et al. 2011). Zhang et al. (2005) addressed the research on semiconductor production line capacity assessment and resource allocation process. A novel fuzzy neural network based algorithm for rescheduling strategies optimization of semiconductor fabrication line was proposed (Uribe et al. 2003). A Petri net with a controller was used to constructing a discrete event model for flexible production line. Resource allocation optimization had been finished by use genetic algorithm and simulated annealing algorithm (Tao et al. 2007). Lin presented a capacity planning model for TFT-LCD production network. A mixed integer linear programming (MILP) was adopted to optimize the capacity planning (Lin et al. 2009). Wang et al. (2005) solve the conflict of capacity planning by describe capacity constraints that include machine tool time table, productivity and machine configuration schedule. An order selection decision model in a make-to-order operation environment based on the short-term capacity-planning problem had been constructed. The mathematical model is proposed to select a set of customer orders to maximize the operational profit and equipment utilization (Chen et al. 2009). Bretthauer put forward non-linear programming for solving multi-period capacity planning with the cost constraint (Bretthauer and Côté 1997). Wang built a model of cooperative capacity planning. An ant algorithm was proposed to solve a set of non-linear mixed integer programming models of the addressed problem with different economic objectives and constraints of market competition (Wang and Chen 2009). Production line capacity evaluation and decision is used to convert as linear or non-linear mathematical programming problems, the problem solving need to utilize some computing intelligent method (Jiang et al. 2009; Wang et al. 2008). The predicted scene with multi associated probabilities was use to simulate the future uncertain demand. A stochastic programming method for capacity allocation decision was proposed to get better robustness (Geng and Jiang 2006; Geng et al. 2009).

These studies above less consider identification and control of the production capacity fluctuation. The paper adopts the control chart method for capacity fluctuation identification and control.

79.2 Production Capacity Fluctuation Control Method Based on the Similar Process

Complex process capability index is used to describe actual production ability of the stable running production line in a given period. Process capability is adopted to evaluate quality fluctuation, and production capacity refers to the ability of processing quantity. Sometimes, process capability is strong, but production capacity may be not high. Production capacity is determined by the bottleneck node of the production line. The node with maximum capacity load rates can be a bottleneck node (Yang et al. 2011).

From a view of statistical, it is difficult to get sufficient and stable data in the multi-varieties and small-batch production model. It is failed to apply classical SPC technology to control the production processes. Similar processes method is adopted to establish capacity fluctuation control charts and monitor production fluctuations of the production line.

Similar process is some processes that have similar quality indicator and similar factor to influence process quality. For example, same equipment, same kind of quality indicator, same kind of manufacturing method, same operator, same material and same environment. The manufacturing node is composed by the same kind of equipment, tools and operator. There are some similar procedure that the compressor blade has similar topology and function. The similar procedure is defined as procedure that same job are allocated on the same manufacturing node in the paper.

The mathematical transformation of quality data is the core of the similar process method. The conversion is built according to similar process of product operation time. The multi-production data can be converted to the data of representative product. The conversion coefficient k_i can be taken as Eq. (79.1)

$$k_i = \frac{t_i}{t_A}(i = A, B, C). \tag{79.1}$$

Here t_i is procedure working hour of similar procedure. A, B, C is three kind of compressor blade.

Small sample can be converted to big sample by the conversion factors between procedure working hours. The control object is total quantity of product. The production fluctuation control model is designed. The equipment available capacity (utilization) is defined as control limit. The available capacity CA is defined as Eq. (79.2).

$$CA = l \cdot t \cdot \alpha \cdot \beta \cdot \gamma \cdot w. \tag{79.2}$$

Where l is number of similar equipment, t is available capacity of single equipment. α is non-plan downtime (%). β is capacity of operator. γ is utilization of manufacturing node. Is allocation percentage from manufacturing node to similar procedure? The up limit and low limit of control chart can be defined by Eq. (79.4)

$$
\begin{aligned}
UCL &= CA/t_A = l \cdot t \cdot \alpha \cdot \beta \cdot \gamma_U \cdot w/t_A \\
CL &= \overline{N_A} \\
LCL &= CA/t_A = l \cdot t \cdot \alpha \cdot \beta \cdot \gamma_L \cdot w/t_A
\end{aligned} \tag{79.3}
$$

Where, γ_U and γ_L is the minimum and maximum utilization of manufacturing nodes expectations respectively. t_A is process working hour of the representative products in the similar processes. $\overline{N_A}$ is described as the mean of total sample. The maximum utilization of equipment may be decided by function, running performance and equipment failure rate. The minimum utilization can be determined by the cost of the product processing. γ_e is an ideal utilization of the manufacturing node as a balanced utilization according to equipment status and production costs. K is a coefficient to evaluate the production process state. The Eq. (79.4) is definition of K.

$$
k = \frac{\overline{N_A}}{CA_e} = \frac{\overline{N_A}}{l \cdot t \cdot \alpha \cdot \beta \cdot \gamma_e \cdot w} \tag{79.4}
$$

From the Eq. (79.4) above, if k is less than 1, the production process does not achieve the desired utilization. If k is equal to 1, the production process achieves the desired utilization. If k is greater than 1, the production process is in an unstable state.

79.3 Production Capacity Fluctuation Control Chart Pattern Recognition Based on SRFM

79.3.1 Regional Supervised Feature Map (RSFM) Network

SRFM network is a new type of neural network, which combines the BP network monitoring and the advantages of SOM network algorithm (Le et al. 2004). It has the strong learning speed, high precision and good scalability and can solve the multi-variable nonlinear mapping problem. SRFM is a kind of three feed forward network. Topology is shown in Fig. 79.1.

SRFM network is divided into input layer, competitive layer and output layer. The connection is full interconnection between input layer and competition layer. The weight of connection can be adjusted. The Hebb learning rule is applied in the process of learning. The connection is local one-way connection between competition layer and output layers. The weight of connection is fixed.

Network use a local supervised competitive learning method. Different pattern region in the competition layer use supervised learning. The same pattern region use unsupervised learning. The process of learning can be described as follow.

(1) Give initial weight vector W_j and connection weight W_{jo} of the input layer and competitive layer randomly

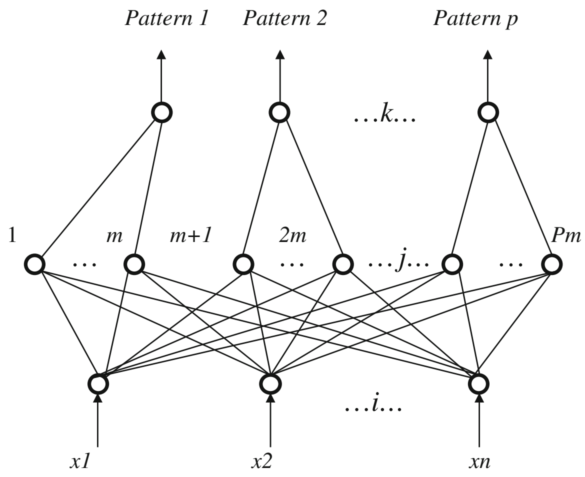

Fig. 79.1 The topology of RSFM

$W_j = [w_{1j}, w_{2j}, \ldots, w_{nj}]; \quad j = 1, 2, \ldots, m \times p; \quad w_{ij} \in (0, 1)$
$w_{jo} = 1/m, o = 1, 2, \ldots, p.$

(2) Input a training sample vector X_k ($X_\mathrm{k} = [x_{1k}, x_{2k}, \ldots, x_{nk}]; \ k = 1, 2, \ldots, I$);

(3) Calculating the Euclidean distance $d_{kj}(t)$ between X_k and all node weight vectors in the competitor layer. t is iteration times. Selecting a competition level node with X_k in the as the winning node g. Selecting a competition level node that the Euclidean distance with X_k as the winning node g

(4) Calculating the output of network according to the Eq. (79.5)

$$y_k = \mathrm{int}[(g-1)w_{jo}] + 1 = \mathrm{int}[(g-1)/m] + 1 \tag{79.5}$$

(5) Adjusting the weight of network. If the network output is consistent to output expected, the weight value need not to adjustment. The next sample X_{k+1} is input to training. On the contrary, the punishment applies on the g point so that the weight vector far away from the training sample X_k. Meanwhile, the point d is selected in the region expect to win (network competitive layer corresponding to the desired output area). The Euclidean distance between point d and X_k is nearest. A reward is applied on the point d so that the Euclidean distance between the point corresponding to the weight vector and training samples is reduced. The Rewards and punishment operator are described by the Eqs. (79.6) and (79.7)

$$\Delta w_{ij} = \begin{cases} \beta \cdot \alpha(\mathrm{t})[x_{ki}(t) - w_{ij}(t)] & j = d \\ -\beta \cdot \alpha(\mathrm{t})[x_{ki}(t) - w_{ij}(t)] & j = g \end{cases} \tag{79.6}$$

Here, β is coefficient of reward and punishment $0 < \beta \leq 1$. $\alpha(t)$ is weight vector correction function.

$$\alpha(t) = k_\alpha(1 - t/t_m) \tag{79.7}$$

Here, k_α is a coefficient of weight vector correction function. t_m is maximum number of iterations.

(6) Input the next sample to study again.if all samples complete to learn, the network completes iteration. And then the network can be transferred to the next time iteration. The process will do until the output error is less than or equal to e_m or the number of training times reach the maximum number of iterations t_m.

79.3.2 Control Chart Pattern Recognition Based on SRFM

(1) The training sample can be gotten by Eq. (79.8)

$$y(t) = \mu + x(t) + d(t). \tag{79.8}$$

Here, t is number of sample. $y(t)$ is production capacity in the time of t. μ is the mean of production capacity in the state of statistical control. $x(t)$ is the capacity fluctuation raised by causal factors in the time of t. $d(t)$ is abnormal interference. $x(t) \sim N(0, \sigma^2)$.

Normal pattern: $d(t) = 0$.

Trend pattern: $d(t) = \pm\rho \times d \times t$. $+, -$ describe upward trend and downward trend respectively. $d \in [0.1\sigma, 0.3\sigma]$. ρ is 0 prior to trend. ρ is 1 after the trend. d is a slope.

Step pattern: $d(t) = \pm v \times t$. $+, -$ describe upward step and downward step respectively. $v \in [\sigma, 3\sigma]$. v is a slope.v is equal to 0 prior to trend. v is equal to 1 after the trend.

Cycle pattern: $d(t) = a \times \sin(2\pi t/T)$.

Here, a is amplitude, $a \in [\sigma, 3\sigma]$; T is cycle, $T \in [2, 10]$.

(2) Data preprocessing

Training or test data must be standardized and normalized before training and testing by network. The normalization can be gotten by Eq. (79.9). The standardization can be gotten by Eq. (79.10).

$$z(t) = [y(t) - E(\mu)]/E(\sigma). \tag{79.9}$$

Here, $E(\mu)$ and $E(\sigma)$ is estimation of μ and σ respectively.

$$z^{'}(t) = [z(t) + 3]/6 \tag{79.10}$$

(3) Selecting the parameter of network

The number of node on the input layer n is 24. The number of node on the output node p is 6. The number of competition layer is $m \times p$. Incentive coefficient

β is 0.8. The adjustment coefficient of weight vector correction function k_α is 0.3. The error of training e_m is 0. Maximum number of iterations t_m is 1000. The coefficient of competition layer m is 10. The number of node on the competition layer is 60.

79.3.3 Result of Training and Testing

According to the parameter above mentioned, the network is trained. The result is shown in Table 79.1. The time of training is 132 s. The rate of recognition error is 0.75 %.

For the six kinds of basic patterns, each of 200 samples is tested. The test results are shown in Tables 79.2 and 79.3. The overall recognition error rate is 2.75 %. The group of 200 normal samples is recognized as abnormal pattern (cycle type), type I error rate is 2 %; 1000 abnormal samples in 9 groups is recognized as a normal mode, the first category of error was 0.9 %.

79.4 Case Analysis

The compressor blade root machining is a key procedure. Three kind of blade are selected for production capacity analysis. Every group sample size is n. The number of unqualified products is d. The sample and working hour are shown in Tables 79.4 and 79.5.

Manufacturing node is not always to work in a certain period of time. In the actual production, some factors that include manufacturing node service capacity, a critical level, personnel skills must be considered to determine shift of manufacturing nodes, working hours and planned service time. These data is shown in Table 79.6.

Table 79.1 Result of training

Nodes	Samples	Time	Iterations	Error rate
10 × 6	200 × 6	132	1000	0.75 %

Table 79.2 Result of recognition

Pattern	Normal	Upward	Downward	Up step	Down step	Cycle
Normal	196	0	0	0	0	4
Upward	0	194	0	5	0	1
Downward	2	0	194	0	3	1
Up step	0	5	0	195	0	0
Down step	2	0	5	0	193	0
Cycle	5	0	0	0	0	195

Table 79.3 Result of testing

Samples	Error of the first kind	Error of the second kind	Total error rate
200 × 6	2 %	9 %	2.75 %

Table 79.4 Samples

No	N_A	D_A	N_B	d_B	N_C	D_C
1	10	1	8	0	10	0
2	10	1	10	2	10	1
3	8	0	6	0	5	0
4	9	1	6	0	7	1
5	11	1	10	2	12	0
6	9	1	8	0	10	0
7	13	1	12	2	12	1
8	12	1	10	2	12	0
9	15	2	12	2	10	0
10	9	1	10	0	10	0
11	7	0	8	2	5	0
12	13	1	10	0	11	1
13	15	1	12	2	11	1
14	11	1	12	0	12	1
15	7	0	10	0	10	0
16	11	2	8	0	9	1
17	11	1	6	0	7	1
18	6	1	4	0	5	0
19	13	2	8	0	12	1
20	11	1	14	2	9	1

Table 79.5 Woking hour and conversion coefficient

Production	Working hour/min	Conversion coefficient
A	40	1
B	60	1.5
C	80	2

Table 79.6 Working sequence

Item	Content
Shift	2
Service time	8 h/shift
Unplanned down time	0.5 h/shift

Then the service time Ts of node is
$Ts = 2 \times 8 = 48$ h/day.
The planned service time Td is

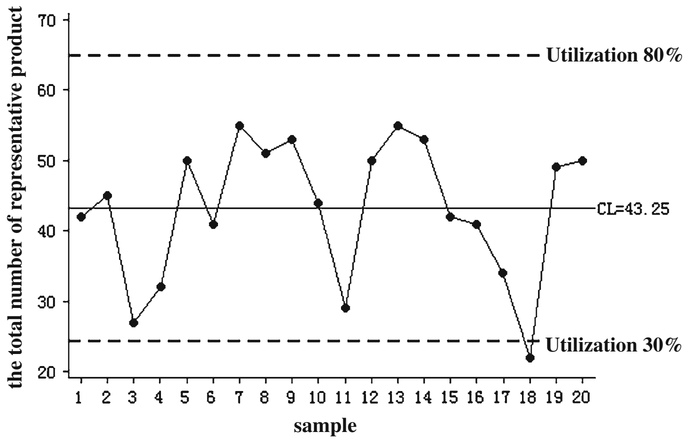

Fig. 79.2 Production capacity fluctuation control chart

$T_d = 2 \times 0.5 = 1$ h/day.

The available capacity of manufacturing *CA* can be calculated according to Eq. (79.11). The available capacity allocated to similar procedure can be calculated according to Eq. (79.12). The maximum utilization expected and minimum utilization expected is 80 and 40 % respectively. And then, the *UCL, LCL* and *CL* production fluctuation control chart are gotten respectively. A production fluctuation control chart can be drawn on the base of data above mentioned.

$$CA = l \cdot t \cdot \alpha \cdot \beta \cdot \gamma = l \cdot (T_s - T_d) \cdot \beta \cdot r. \tag{79.11}$$

$$CA_d = CA \cdot w = l \cdot (T_s - T_d) \cdot \beta \cdot r \cdot w. \tag{79.12}$$

$$\begin{aligned} UCL &= CA/t_A = l \cdot (T_s - T_d) \cdot \beta \cdot r_U \cdot w/t_A \\ &= 6 \times 15 \times 60 \times 1 \times 80 \times 60\,\%/40 \\ &= 64.8 \end{aligned} \quad \begin{aligned} LCL &= CA/t_A = l \cdot (T_s - T_d) \cdot \beta \cdot r_L \cdot w/t_A \\ &= 6 \times 15 \times 60 \times 1 \times 30 \times 60\,\%/40 \\ &= 24.3 \end{aligned}$$

$$CL = \overline{N_A} = 43.25.$$

The 18th data falls below the minimum utilization level by analysis chart. The production capacity is in the abnormal state. The *K* can be gotten by calculation.

$$\begin{aligned} k &= \frac{\overline{N_A}}{CA_e/t_A} = \frac{\overline{N_A} \cdot t_A}{l \cdot t \cdot \alpha \cdot \beta \cdot \gamma_e \cdot w} = \frac{\overline{N_A} \cdot t_A}{l \cdot (T_s - T_d) \cdot \beta \cdot r_e \cdot w}. \\ &= \frac{43.25 \times 40}{6 \times 15 \times 60 \times 1 \times 60 \times 60\,\%} \approx 0.89 \end{aligned}$$

Because *K* is less than 1, we can see that the production process does not meet the ideal utilization.

Production capacity fluctuation control chart can be drawn according to the Table 79.5. the chart is shown as Fig. 79.2.

79.5 Conclusion

A model of capacity fluctuation control has been established. Nonconforming rate control chart and capacity fluctuation control chart based on similar process has been designed. A method to calculate process capacity index and production capacity evaluation index is proposed. Pattern recognition for capacity fluctuation based on SRFM network is built. The aero-engine compressor blade production fluctuation case is used to verify right of method above mentioned.

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Chapter 80
Standardization of Government Supervision Business Decisions for Construction Quality

Han-ding Guo, Xing-neng Ma, Li-zheng Lei and Yin-xian Zhang

Abstract Standardization of government supervision business decisions for construction quality is the core of scientific and effective operation of the standardization system of supervision decision-making which is in record to standardization of performance evaluation and assessment. The expression form of supervision business decisions standardization requires expression standardization of supervision results. The nature that the decision is based on should be legalized; the process of performing decisions should be scientific; the evaluation that decisions sustain should be generalized; the decisions of completion for the records sparkplug comprehensive; the form of evaluation and decision-making should be standardized.

Keywords Business decision · Construction quality · Government supervision · Standardization

80.1 Introduction

Standardization of government supervision business decisions for construction quality, whose foundation is standardization of performance evaluation and assessment and whose expression form is standardization of supervision results expression, is an important component of standardization system of supervision decision-making, and scientific reflection on the standardization system operation of supervision decision-making. It is a core link of the effectiveness of government

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supervision for construction quality, and it will advance the standardization system of government supervision for construction quality orderly operation.

80.2 Framework of Standardization System of Government Supervision and Decision-Making

The process of government supervision organizations for construction quality is that the quality supervisor carries out all-round and comprehensive patrolled supervision and evaluation decision. Patrolled supervision is the basic method and evaluation decision is the basic content, supervision process for construction quality can't live without the supervisor making scientific analysis and accurate judgment according to the law. Standardization system of supervision decision-making consists of expression standardization of supervision results, standardization of supervision decision-making and assessment standardization of performance evaluation (Guo et al. 2010a). Standardization system of supervision decision-making is shown in Fig. 80.1.

80.3 Standardization Systems of Supervision Business Decisions

Government supervision for construction quality is that the man who has the qualification for the ability to conduct supervision on construction body's quality action, foundation and main body structure engineering that might affect the safety service, as well as building energy efficiency and environmental quality. Its purpose lies in ensuring construction engineering safety use and environmental quality, and its basic rests with maintaining the state and public engineering

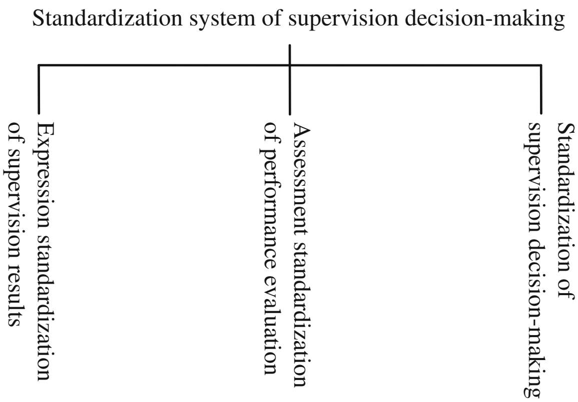

Fig. 80.1 Standardization system of construction quality supervision and decision-making

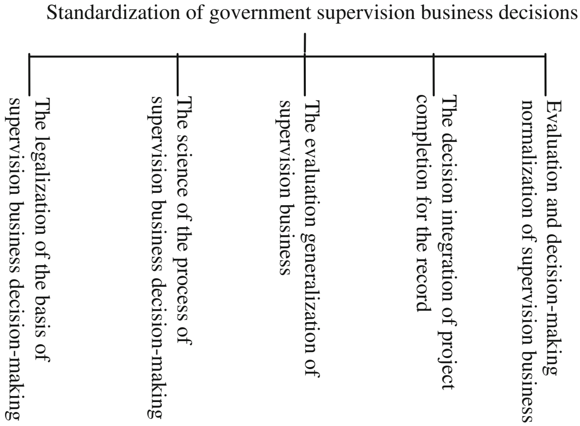

Fig. 80.2 Business decisions standardization of government supervision

quality interests. The process of supervision for construction quality is that the supervisor makes the judgment and decision-making whether the construction quality meets demand or not on the basis of the legal standards and actual evaluation and analysis. To improve the effectiveness of government supervision of construction quality, it is necessary to implement standardization of government supervision business decisions which includes the legalization the basis of supervision business decision-making, the science of the process of supervision business decision-making, the evaluation generalization of supervision business, the decision integration of project completion for the record, evaluation and decision-making normalization of supervision business (Guo et al. 2008). The details of business decisions standardization of government supervision are shown in Fig. 80.2.

80.4 Connotation of Standardization of Supervision Business Decisions

80.4.1 Legalization of the Basis of Supervision Business Decision-Making

Government supervision for construction quality is a law enforcement supervision which is based on laws and regulations and mandatory standards. Supervision business decision-making for construction quality should be on the basis of laws and regulations, concretely speaking, in the light of architecture law, quality management rule of the construction project and mandatory standards for construction projects and so on to implement government supervision. And whether the construction quality is up to the mustard or not is in the light of the stands that laws and regulations set (Zhang et al. 2008). Laws and regulations are the basic parameter for supervision business decision-making for construction quality, and the legalization of decision-making basis is the essential requirements for oversight of law enforcement.

80.4.2 The Science of the Process of Supervision Business Decision-Making

It's the inherent law for construction quality forming process that makes the organic process of beforehand control, intermediate control and afterwards control of construction quality supervision (Li and Zhou 2010). The science of the process of supervision business decision-making is to scientifically implement beforehand supervision business decision-making, intermediate supervision business decision-making and afterwards supervision business decision-making. Specifically, before supervision performance, it needs to evaluate the implementation for construction quality ability, control the construction conditions, determine the focus of the project supervision scientifically, and assign task reasonably; during the course of construction, it needs to implement comprehensive evaluation of the whole forming process of quality and the results concentrating on the foundation, the main body structure, energy conservation project and environmental quality as the supervision focus, making the main quality cooperated-building behavior as supervision core, going on a tour of inspection as the main form; in the process of the completion acceptance and record, it need to carry out comprehensive evaluation and decision of completed for the record based on the process and result of completion acceptance, and combined with supervision process (Guo et al. 2010b). Not only does it have forehand evaluation and decision-making, it also has focus evaluation and decision-making in the process, what's more, the comprehensive afterwards evaluation and decision-making is also included. By doing that, it can form scientific and systematic system of supervision evaluation and decision-making combined with beforehand decision, intermediate decision and afterwards decision.

80.4.3 The Evaluation Generalization of Supervision Business

The many factors and complexity of construction quality decide the comprehensiveness of the quality evaluation. The evaluation generalization of supervision business not only reflects overall process evaluation, but also reflects all the factor evaluations; it not only evaluates conditions of the quality forming, but also evaluates the process and result of the quality forming; it not only takes quality data into consideration, but also analyses the reliability and authenticity of the quality data source; it not only appraises construction quality codes, but also appraises the conformity of construction quality result (Guo 2003, 2004). Implementation of capacity assessment for construction quality should take engineering project attribute, engineering design level, construction main body ability, and constructing environment into consideration (Guo and Wang 2006a). Engineering project attribute can be reflected from the construction project scale, project complexity, and construction technology progress and project quality requirements; engineering design level can be reflected from the quality of construction drawing design and design inspection; construction main body ability can be reflected from construction owners, the design units, supervision units and construction units; constructing environment can be reflected from building market, building material market, quality testing market and social security. As for partitioned project that involves safety use such as foundation, major structure, building energy efficiency and environmental engineering should take construction main body quality behavior, quality actual input, quality implementation process, quality output results, quality spot check into comprehensive consideration. Construction main body quality behavior can be reflected from construction owners, the design units, supervision units, construction units and testing unit; engineering quality actual input can be analyzed from construction management plan, supervision planning and implementation, quality management system and execution, quality management agency and responsibility, construction machinery choice, detection means and measuring tools, material supply contracts and management, construction operation personnel responsibility and ability, construction management personnel's responsibility and level; quality implementation process can be analyzed from proportioning list and assay rate, the construction technical clarification, construction site management, the quality guarantee system and operation, site supervision and record, the material quality inspection and acceptance, construction standard implementation, construction process inspection and acceptance, the procedure hand over inspection and record, workers' mental state and spirit, machinery status and maintenance, inspection method and application tool; quality output results can be analyzed from subsection acceptance, subsection inspector, subsection evaluate results, acceptance record of concealed work, material and equipment quality check list, supervision engineer quality instructions, the engineering quality inspection data, test results of briquettes and test specimens, quality inspection personnel's ability and level, the construction diary and quality problem processing records; quality spot check can be reflected from sub-divisional work spot checks records, material and equipment spot checks records, machine operating inspection records, related personnel quality consciousness, field staff operation specification. Assessment and completion for the record for construction quality should take engineering design quality, construction quality, material and equipment quality, construction main body quality action and site entity quality into consideration. Design quality can be reflected from design documents quality, the design review quality, design alteration quality; construction quality can be reflected from completion checking grade, acceptance personnel qualifications level and reputation, conditions of checking the material, the checking organization and procedures; material and equipment quality can be reflected from the equipment material suppliers' qualification, credit, quality assurance system, quality activities, field inspection and witness inspection, qualification, credit, quality assurance system, quality activities of testing organizations; construction main body quality action can be reflected from the owners' quality management system and quality behavior, quality management system and quality behavior of supervision unit, quality management system and quality behavior of survey and design units, and quality management system and quality behavior of construction units; site entity quality supervision can be reflected from quality supervision of the foundation, major structure and construction environment quality.

80.4.4 Decision Integration of Project Completion for the Record

Project completion for the record whose purpose is to evaluate the engineering project quality level and maintain the state and public construction project quality interests is a behavior that government supervision for construction quality pays great attention to the completion and put into service (Guo 2006). The decision integration of project completion for the record which is in the light of the evaluation generalization should take project quality, material quality and supervision process quality into consideration; and conducts comprehensive quality evaluate on the design that involves design documents quality, the design review quality and design alteration quality; it should conduct comprehensive quality evaluate on completion checking grade, acceptance personnel qualifications level and reputation, conditions of checking the material, the checking organization and procedures; it should conduct comprehensive quality evaluate on the equipment material suppliers' qualification, credit, quality assurance system, quality activities, field inspection and witness inspection, qualification, credit, quality assurance system, quality activities of testing organizations; it should conduct comprehensive quality evaluate on the owners' quality management system and quality behavior, quality management system and quality behavior of supervision unit, quality management system and quality behavior of survey and design units, and quality management system and quality behavior of construction units; it should conduct comprehensive quality evaluate on site entity quality that involves quality supervision of the foundation, major structure and construction environment quality; scientific decision of completion for the record is made in the light of comprehensive analysis (Guo and Wang 2006b). The decision integration of project completion for the record is the requirement that reflects engineering quality level and realizes strict checks on the completion and safety use.

80.4.5 *Evaluation and Decision-Making Normalization of Supervision Business*

Evaluation and decision-making of supervision business mainly involve evaluation of quality implementing ability, assessment and quality supervision of the main partitioned project and comprehensive evaluation of completion for the record. And all the assessments and decisions not only take qualitative index factors into consideration, but also include simple unified quantitative method. Every evaluation should have explicit assessment organization and responsibility system, every part of the evaluation should be set up as required to perfect the evaluation mechanism, standardize evaluation program, unified the evaluation and decision conclusions, and make feedback of evaluation and decision results meet with legal requirements. Evaluation and decision-making of supervision business is the basic pathway to improve the science of the decision (Guo and Wang 2006c).

80.5 Conclusion

Government supervision standardization for construction quality is an important pathway to improve the efficiency of government supervision for construction quality and ensure the effectiveness of government supervision for construction quality. Government supervision standardization for construction quality should set up both supervision process standardization system and supervision decision-making standardization system. The core of supervision decision-making standardization lies in the standardization of supervision business decisions which includes the standardization and the normalization of supervision business basis, process, support, completion for the record and the modality. The essence of the process of government supervision for construction quality is a process to make supervision decisions constantly (Guo 2005). It is a basic premise of ensuring the supervision scientific and authoritative to put the standardization of supervision business decisions of construction quality into effect.

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Chapter 81
Study on Integrated Design Quality Mode Based on QFD and DOE

Tongbing Ma

Abstract Design for Quality (DFQ) is a design concept for product quality. In the product design stage, it uses reasonable theory or method and accurately grasps the needs of the market. Then the customers' needs and the quality characteristics will be combined into the product design process. Based on contrasting and analyzing the characteristics of Quality Function Deployment (QFD) and Design of Experiment (DOE) in details, the p puts forward the integration frame of these two design tools. It will not only exert each advantage and compensate each shortage, but also increase product design quality and construct competitive advantage for satisfying the customers.

Keywords Quality design · Quality function development · Design of experiment · Integration

81.1 Introduction

Product design is the soul of the manufacturing industry, but also the internal impetus of enterprises survival and sustainable development. This is because product quality is designed firstly, and then produced depending on advanced manufacture technology. In the product design stage, the design decision of products mostly influences on the quality and cost of the throughout life cycle;

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at least 80 % of the product qualities are determined at this stage. Product design determines the inherent quality and product whether can meet customers' needs and bring benefit for business and society. Therefore, to improve product quality must start from scratch, the "Design for Quality" came into being.

The concept of Design for Quality (DFQ) was originated from the end of the 1980s, its basic idea is to combine product quality requirements and quality characteristics into the product design process. It accurately grasp the market and customers' demands and take full account of the quality requirements and quality objectives at all stages of the throughout life cycle of product so as to shorten design time and reduce design costs. Among them, how to transform customers' needs into quantifiable design characteristics is an important feature that a good design must have. In the current design theories, Quality Function Deployment (QFD) can solve the problems of "what to do" and Design of Experiment (DOE) can solve the questions of "how to do". The two organic combinations can provide a strong integrated support tools for the design for the product quality. Therefore, this article will analysis and research the integration model of the two methods.

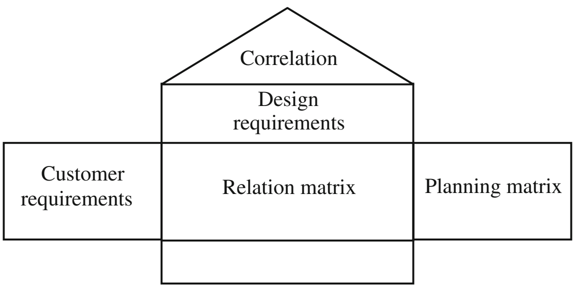
81.2 The Foundation of QFD and DOE's Integration

81.2.1 QFD

QFD was firstly applied by Japanese enterprises, and they achieved significant results in the Twentieth century 1970s. It was introduced to the United States in the 1980s and later gradually extended to other countries. QFD is a way of product design method which combines customers' demands with product quality closely and always requires focusing on the needs of customers in development design and implementation process of the product.

Specific methods of QFD: it transforms the customers' requirements into functional properties of product firstly and then the functional properties of product will be further expanded into the required elements technologies, and give a direction for the product design and process design through a clear required

Fig. 81.1 The constitute of HOQ



elements technology and its import degree. It vividly provides evidence for the design decisions of the each stage of product development through table and data. The core part of the QFD is House of Quality (HOQ), as shown in Fig. 81.1. It is the vector of QFD using waterfall model disintegration of matrix, set up the relationship between customer demand and design requirements and support design and the whole manufacturing process.

QFD collects all product-related information of customers and brings some important problem, related characteristics and target value of products to the customer demand in order to achieve consistency, thereby reducing the customer needs and estrangement that exist among product manufacturers. QFD as a customer-driven product system design methods can effectively guarantee the accuracy of demand to transform into requirements of the next stage. Therefore, QFD, which was introduced in the product development process can guarantee customer needs not to be distorted in the whole life cycle, avoid unnecessary redundancy, reduce consumption of maintenance and operation on the process of application, so that enterprises get the greatest economic and social benefits in the circumstance that product can meet the demands in maximum.

81.2.2 DOE

Design of Experiment (DOE) is a mathematical statistics method about arrangement for testing and analysis of test data. Now, it is mainly formed two mainstream branches: the one is represented by the classical design of experiment studied by an American statistician G. E. P. Box, which mainly includes comparative tests, full-factor tests (or factorial experiments), fractional factorial tests, Response Surface Method (RSM) and so on; the other is Taguchi Method proposed by the Japanese quality-control specialist Dr. Taguchi, and who succeeded in combining DOE and the concept of cost and proposed three stage design, loss function, signal to noise ratio and inside and outside array etc. Although these two methods about design of experiment use different design techniques, both of them use statistical methods to achieve robustness design and optimization of product and process.

DOE is an active design behavior, a kind of control method about offline quality. Its purpose is to understand the relation between input and output, to find out the main factors that affect quality characteristics of product and process and to determine optimal level and control range of quality characteristics of product and process so as to fundamentally improve quality and performance of products.

81.3 Study on the Integration Model of QFD and DOE

We can see from the above: QFD and DOE have their unique main function, QFD is based on the needs of customers to develop products and to be launched at various levels to ensure the quality of design and reliability DOE through statistical analysis of data to find out the design scheme which owns most stable performance and the lowest cost in order to better meet customer demands. But they have the same purpose: they are based on customer satisfaction and driven by minimum social loss to seek ways to reduce the mass loss in order to improve design quality and produce the products that meet with customer requirements. They guarantee quality design for product from different angles and different aspects. Therefore, the integration of QFD and DOE for product design and quality control will help optimize product design, development and manufacturing process so as to improve and enhance product quality.

The integration of QFD and DOE will not disrupt the existing product development process, but integrate into the one on the basis of the existing product development process. Product development processes include four stages: definite task, conceptual design, preliminary design and detailed design, as shown in Fig. 81.2. The four stages are the foundation of the integration of QFD and DOE, which can be carried out by order or in parallel. On this basis, QFD and DOE integrate their respective theories and methods into the product development process to provide strong support for the product development process at all stages.

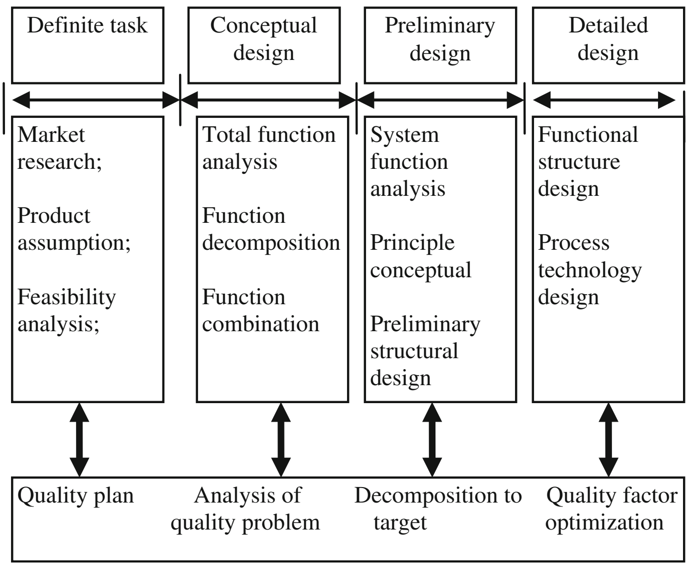


Fig. 81.2 The quality process of product design

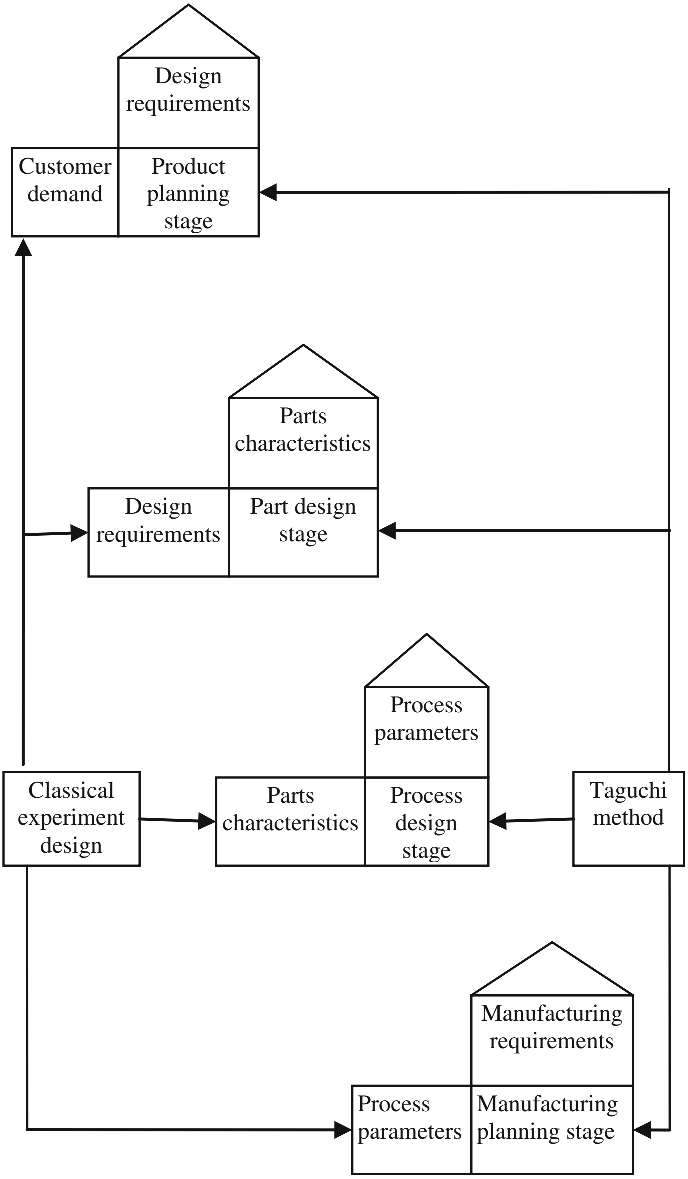


Fig. 81.3 QFD and DOE integrated model

First of all, the person's experience usually distinguishes the relationship of among different the product quality characteristics, the relationship between product quality characteristics and process quality characteristics and the relationship between parts quality characteristics and process parameters in the traditional QFD. Especially in the “Planning Matrix” stage, relevant experts or customers are generally employed to evaluate customer requirements of the product of the business and competitive enterprise, the evaluation methods are the each customer requirement of the taken product is given different scores, the higher scores indicate that products meet customer needs better. However, because of the subjectivity of appraising personnel, the above evaluation methods may have some errors. Therefore, there must be evaluation based on objective criteria that required for different products to meet customer demand. The method is to use quality loss function of the Taguchi method of experimental design to determine the value of the products of different enterprises in customer mind, the smaller the loss shows, the better the stability of products is, and the higher customer evaluation of products is. In this way, enterprises can quantitatively determine the product quality. Secondly, in the phase of “Customer demand and its importance” of QFD, factorial experiment can be done with experimental design methods, selecting different quality characteristics of the existing products as a factor and different characteristic value of quality characteristics as the level. Through understanding what characteristic values of existing quality characteristic are customers wanted by mathematical statistics methods; new product development and design will be more pertinence. On the other hand, the primary role of DOE, which has been widely used in the product and process design and development phase, is to define the correlation between target value and influencing factor of the product or process, but with DOE as a kind of engineering tool, customer needs are less considered. Integrated with QFD, DOE can guarantee more consistencies with the customer-driven objectives.

Therefore, the comprehensive application of QFD and DOE will not only compensate each shortage, but also exert each advantage. Specific integration model of QFD and DOE is shown in Fig. 81.3.

81.4 Conclusions

Although the QFD and DOE have each limitation, both of them also have similarities. Therefore, the use of the integration can make up for their shortcomings and play a greater advantage. The integrated model of QFD and DOE is a strong tool of product design and quality control, which guarantees the quality of product design from different sides and different angles in order to produce products that can more meet customer requirements. With the arrival of the 21st century, the increasingly fierce market competition, enterprises R & D (research and development) personnel and engineers of enterprises should understand and master this method, apply to practical work, develop and design the high quality products to meet customer requirements, so that enterprises always keep their competitive advantage.

Chapter 82
Study on Product Lifecycle Oriented Product Design Quality Control System

Xing-yu Jiang, Long-zhen Xu, Xin-min Zhang and Ye Bian

Abstract How to assure product design quality has become the key to quality control in product lifecycle. Quality forming process in product design is studied in depth. On the basis, organization and function model of product lifecycle oriented product design quality control system are established, integrated several key technologies such as collaborative quality design method, task distribution of quality design, integrated technology. Java, JSP and JavaServlet are applied to design and develop the system, which is introduced as the example of some automobile to verify that the system developed would efficiently improve efficiency and shorten the development cycle so as to respond to the fluctuation of market demands as quick as possible.

Keywords Product lifecycle · Product design quality · Task distribution · Customer requirement

82.1 Introduction

As the trend of economic globalization is continuously enhanced, enterprise faces more and more market competitions. In order to survive and development, enterprise has to push out the product that meet the requirements of market with quicker speed (time to market), higher quality, lower cost and better service. Obviously, quality has become the key to market competition (Flynn and Flynn 2005).

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However, product quality is formed in the total product lifecycle; inherent product quality depends on product design quality. Quality experts and designer found that most of quality problems or defects in production and use are the reasons of the faults in the product design process according to many years practice and statistical analysis, and the quality problems in design process are difficult or even unable to be corrected in the later of product lifecycle (Krause 1993). Therefore, reducing quality problems in design stage has been the most important part of product quality control.

While, conventional quality design is serial design mode oriented product design process, so that couldn't consider manufacturability, assembling and maintainability as soon as possible, and lacked another departments of production (Jiang et al. 2007a, b), which results to the disconnection between design and manufacturing process, poor design quality, interminable product developing time.

Therefore, formation process of product design quality process is analyzed in depth, organization and functional model of product lifecycle oriented quality design are established, and the key technologies of product lifecycle oriented design quality control are studied, prototype system of product lifecycle oriented design quality control system is designed and developed, which can realize organ integration of collaborative design and quality control.

82.2 Formation Process of Product Design Quality

Product design quality is formed in the process of product design, and quality characteristic of product is gradually clear in the deepening of design process. The factors that influence product design quality distribute in the total process of product design. With the gradual and further design process, quality characteristic is gradually thinned, which is reflected to each detail of design scheme, total quality of product design is formed finally. Generally speaking, according to the studies on influencing factors of quality in the process of product design, they are summarized as the follows:

(1) *Customer requirement.* It is reported that 40 % of the errors in design process are caused design, if deviations appear in the link, design quality must be greatly influenced.
(2) *Serial design mode*. In the studied cases of product engineering change in aviation, industry and automobile, about 70 % of product engineering rework is caused by the reasons that customer expectation can't be satisfied and production capacity of workshop isn't be considered, over 40 % of product engineering rework is not found until production began. Therefore, the serial design mode couldn't meet the requirements of quality control in the process of current product design.
(3) *Designer and organization*. Designer can influence product quality and developing cost greatly. Furthermore, modern product, with complex structure

and covering a wide range, needs an organization composed of engineers that come from different stage of product lifecycle, which can consider process, manufacturing, assembly etc. in product design process.

(4) *Quality information and tools*. In product design process, quality information is very important for designers, which is main quality control object. Furthermore, designers need apply tools of quality design to assure product design quality. So, quality design platform is needed to integrate quality information and the tools of quality design, which makes designers choose suitable tool for task and apply quality information rapidly and conveniently.

82.3 Organization Model of Product Lifecycle Oriented Product Design Quality Control System

As process, manufacturing, assembly etc have to be considered in the process of product design, the organization must be composed of engineers come from different stages of product lifecycle. However, the development of computer and network technology makes designer breakthrough the bounds of departments or enterprises. So, organization that is trans-department, trans-region are established, which is composed of designers have relevant design ability come from all over the global. In order to assure the collaborative quality design, the organization model of product lifecycle oriented quality design has changed flexible organization mode that has the product quality or task as its core from the former rigid organization mode that has functions as its core. The organization model of the product lifecycle oriented quality design is shown in Fig. 82.1.

In the process of product design for lifecycle, quality design group is essential organization unit. In order to meet the requirements of product lifecycle oriented design quality control, the quality design group is composed of quality experts, representatives of respective functional department, customers and suppliers. Designers play different roles in the quality design group according to responsibility. Generally, a quality control group is composed of group leader, quality expert and designers, and person in charge in different stages of product lifecycle (or corresponding person which takes charge of technology) takes charge of group leader. Every designer corresponds to some authority (task configuration, task receive etc.), which is dynamically configured according to the actual condition.

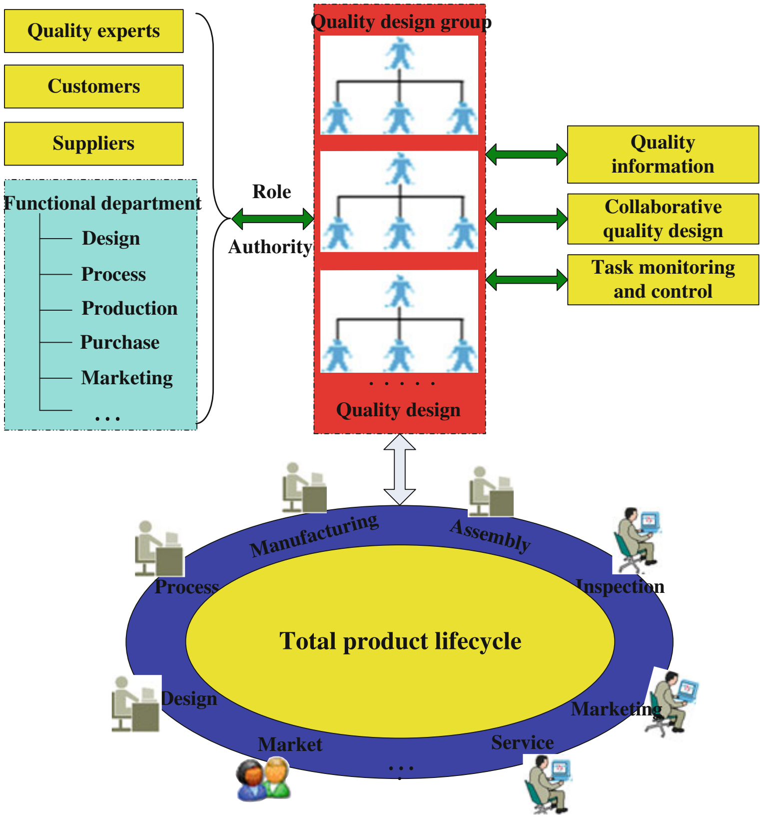

Fig. 82.1 Organization model of product lifecycle oriented product design quality control system

82.4 Functional Model of Product Lifecycle Oriented Product Design Quality System

Designers that come from different stages of product lifecycle, supplier and customer could participate in product lifecycle oriented design quality control system, which can obtain the customer individualized requirements accurately, which are converted into product quality characteristic, technical methods and assurance measurements in the process of product design. The functional model of product lifecycle oriented product design quality control system is shown as Fig. 82.2.

(1) *VOC* (*Voice of customer*) (Jiang et al. 2010). It is very important method of obtaining customer individualized requirements. The technologies of computer network and artificial intelligence (such as artificial neural network, case-based reasoning etc.) are applied to obtain and analyze customer requirements, and to form VOC reports of customer.

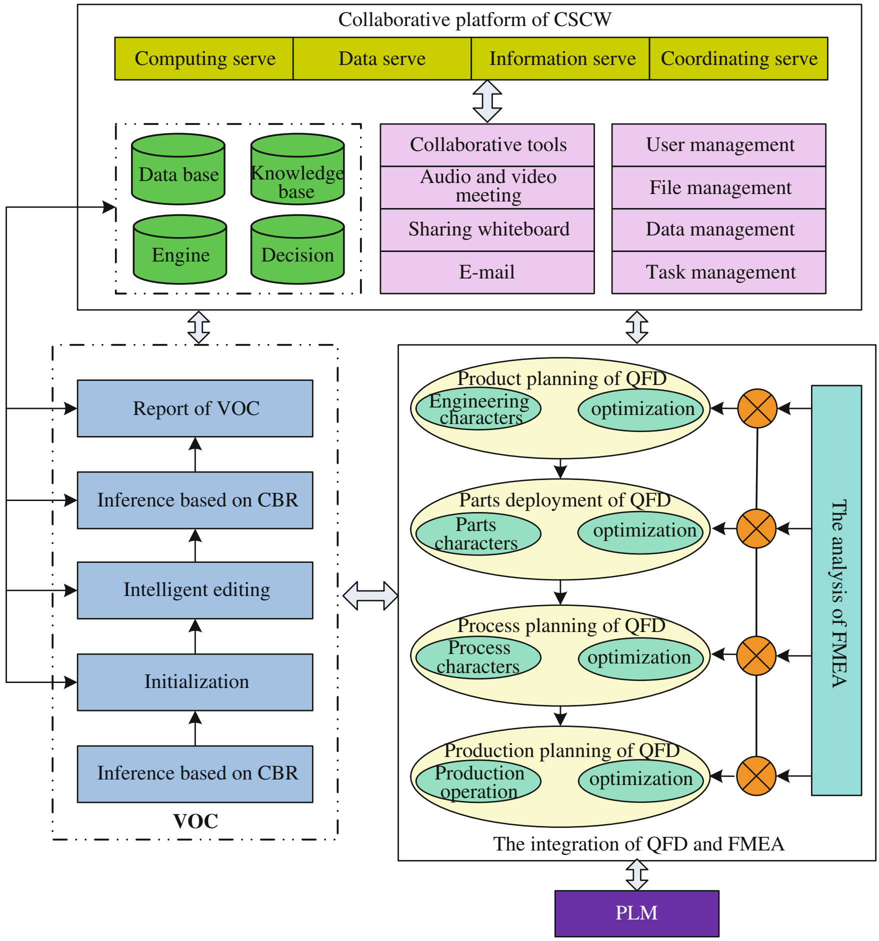

Fig. 82.2 Functional model of product lifecycle oriented product design quality control system

(2) *Quality design method*. QFD (quality function deployment) (Zhong and Zheng 1996) and FMEA (failure mode and effect analysis) are applied to convert customer requirements into product quality characteristic and find potential quality risks. QFD and FMEA are integrated by OLE mechanism.

(3) *Quality design platform based on CSCW* (*computer supported collaborative work*) (Guan et al. 2004). Quality information and quality tools are integrated in the platform. Furthermore, customer can login the platform to participate the quality design of product directly, interact with designers in real time to correct and adjust quality design scheme of product. Therefore, customer requirements may be met to maximum extent, or adjustment later for changes of customer requirements was reduced, which improve production efficiency.

82.5 Key Technologies of Product Lifecycle Oriented Product Design Quality Control System

82.5.1 Collaborative Quality Design Method

CE (concurrent engineering) is applied to do with the problems resulted in serial design mode (Wang and Tang 2003, 2006). QFD is an important tool of DFQ (design for quality), which orients to CE. But, there are some problems in its use by itself.

When QFD is applied by itself, sometime customer's requirements are emphasized excessively, furthermore customer's requirements after four phases of QFD are distorted because of their variability; in addition, a series of numbers (such as 1, 3, 9 etc.) of QFD matrix can't reflect the complicated relationships between engineering characters or customer's requirements and engineering characters. For FMEA, it is a fussy and time-consuming process; furthermore enumerating failure mode is the process of applying brain storming, which depends on abstract thing and summarizing experience in the past. So the method may omit failure (potential failure) mode very easily, which resulted in non-reparative consequences.

Therefore, FMEA is applied to combine with QFD, which obtains optimum conceptual design Scheme. Then, collaborative quality design method is put forward, which combines QFD and FMEA. The analytical objects of FMEA are determined by QFD, and preventive measures are determined by FMEA, which are fed back to the corresponding phase of QFD to conduct further process of QFD.

82.5.2 Task Distribution

Usually, market requirements are the starting points of driven collaborate quality design. The core enterprise determines product quality object by analyzing customer requirements, which includes quality characteristics and key quality parameters. Because of complexity and shortened lead cycle of modern product, it is impossible to complete the whole process from product design to after-sale maintenance (that is total life cycle of product quality) (Liu and Zhang 2006). Therefore, product and its quality object need to be decomposed, and then the decomposed quality objects are distributed to the corresponding cooperative enterprises in the form of task. And the quality design task has become the link that connects all the collaborative quality design, the decomposition process of quality design task is shown in Fig. 82.3.

The task distribution process of collaborative quality design can be formulated as Eq. 82.1:

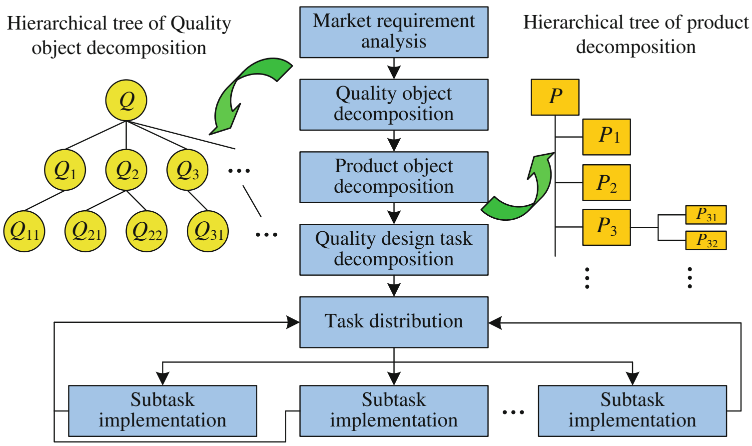

Fig. 82.3 Process of task distribution

$$CQD = \sum_{i=1}^{n} \sum_{j=1}^{m} Q_{ij} \tag{82.1}$$

In Eq. 82.1, n is total number of inclusive phases in the process of quality design; m is total number of cooperative enterprise; Q_{ij} is task that cooperative enterprise j undertakes in i phase.

It is obvious that task quality design object can connect with cooperative enterprise, quality characteristic and parameter by quality design task. Quality design object is the power driving task implementation, step by step decomposition and thinning of the object is task decomposition and iterative process of task implementation. Cooperative enterprise is implementing task agent, step by step decomposition and thinning of the task is the process of task distribution and implementation, is collaborative and concurrent process among cooperative enterprises too.

82.5.3 Integrated Platform of CSCW

In order to realize collaborative quality design, CSCW architecture is needed to be constructed, which is composed of CSCW tools, quality information sharing, quality tools etc., consequently. The integrate platform of CSCW could be divided into four layers: communication layer, quality information layer, collaborative working layer and application, which is shown as Fig. 82.4.

(1) *Communication layer*. It provides communication tools between QFD deployment and FMEA analysis, which are applied to collaboratively complete by all designers. Therefore, the tools seemed especially important to

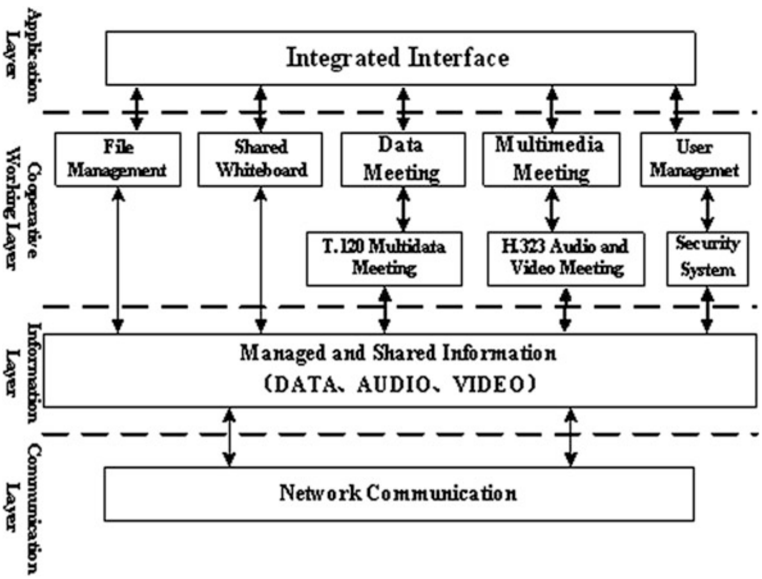

Fig. 82.4 Integrated platform of CSCW

assure quality. These tools mainly are composed of two categories: one category is the asynchronous communication tool collection; the other category is the synchronous communication tool collection.

(2) *Quality Information layer*. Quality information was integrated and shared in the whole process of product designs, the integrating and sharing tools can record the design process and share the related quality information easily. In the process of product design, we also should fully consider the traditional QFD material and the design documents, as well as the safety.

(3) *Collaborative working layer*. In the process of product design, quality design group needs the sharing work space respectively, which made them realize collaborative operation on some same task. The main tools included: whiteboard, QFD collaborative edition, FMEA collaborative analysis, collaborative discussion and so on.

82.6 Application of Product Lifecycle Oriented Product Design Quality Control System

The overall structure of product design quality control system is showed in Fig. 82.5, which is divided into three layers including the top layer, the Middle layer and low layer. The top layer is the Internet, and it combines the related entities such as the related enterprises, institutes and universities and so on to

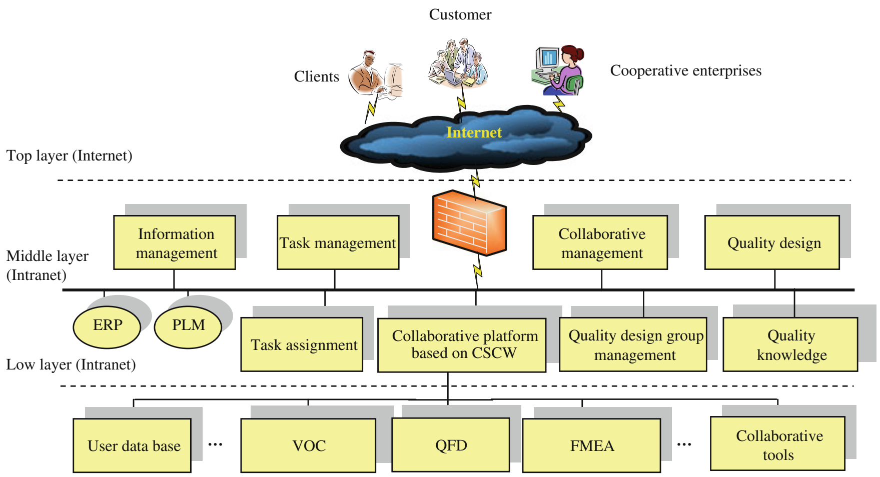

Fig. 82.5 System structure of product lifecycle oriented quality design system into supply chain

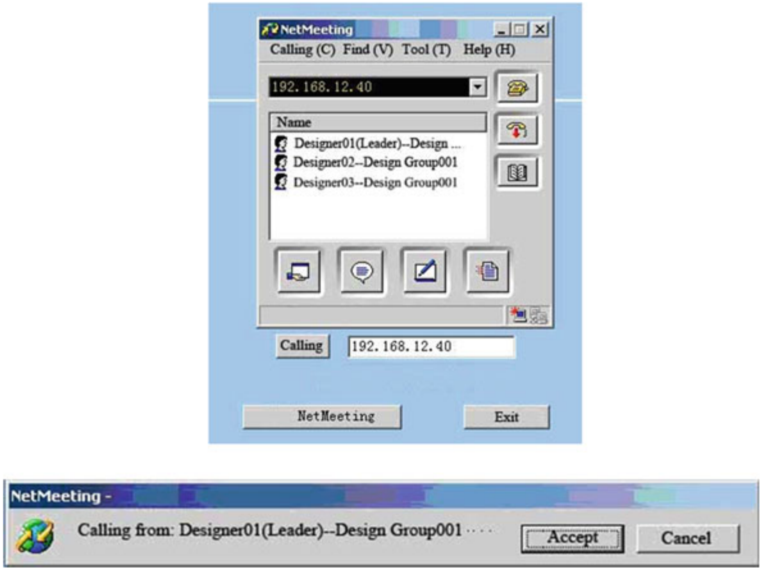

Fig. 82.6 Sketch map of convening coordinate meeting

implement the share of information resources and the cooperative integration of product lifecycle oriented quality design based on the Internet; the middle layer is the Intranet or LAN, it is responsible for the activities.

The system comprehensively applied technology of Java, JSP, JavaScript, JavaServlet and so on, and took SQL Server2000 as background database, and took Windows2000 as the development platform of server. Furthermore, Microsoft

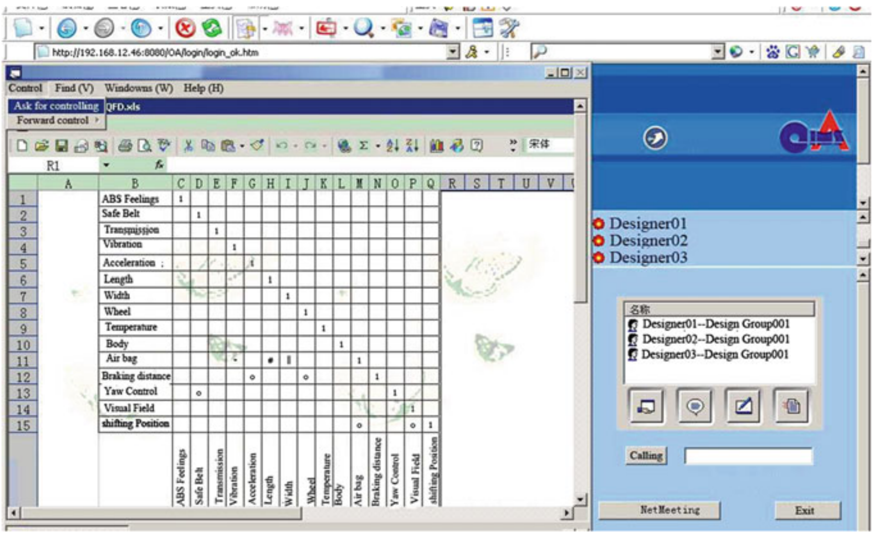

Fig. 82.7 Designer 03 asked designer 01 for controlling shared QFD design platform to edit HOQ

Corporation's NetMeeting multimedia meeting software is embedded into it. The multi-spots and multimedia meeting system is constructed, which supported the multimedia communication (included whiteboard, the document exchange, audio, video, image and so on). As an enabling platform, the system provided the interface with group activities by applying software tools that could collect information.

That sketch map of convening collaborative meeting. Designer 01 is responsible for collaborate meeting, and provided the design platform of QFD and FMEA to share with designer 02 and designer 03, is shown in Fig. 82.6.

That designer 03 asked designer 01 for controlling shared QFD design platform to edit HOQ is shown in Fig. 82.7. Then as soon as he is approved by designer 01, designer 03 can edit HOQ. Furthermore, designer 01 and designer 02 share real time HOQ that is edited by designer 03.

82.7 Conclusions

Forming process of quality in product design is analyzed in depth, organization and functional model of product lifecycle oriented product design quality control system is constructed, and the key technologies are studied in this paper. Furthermore, the prototype system was developed by Java, JSP, JavaServlet, and it was showed in detail by the example of quality design of some automobile shows the system feasibility. Therefore, this study in this paper is very significance of improving efficiency, shortening product development cycle, and assures that product can meet the customer requirement throughout product lifecycle.

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Chapter 83
Temperature and Humidity Precise Control of Greenhouse Based on Nonlinear Model

Zeng-shuai Qiu, Xiang-dong Wang and Qian Gao

Abstract Aiming at the high-precision mechanism model of the greenhouse and the problem of the nonlinear strong coupling between temperature and humidity, this paper employs the method of accurate linearization in the nonlinear system. The exact linearization of the system is realized through state feedback, and then realizes the asymptotically tracking of the ideal output of this system. It is shown by the simulation of MATLAB software that the controller designed has favorable performance, and is able to track the objective curves of temperature and humidity.

Keywords Exact linearization · Greenhouse · Humidity · Nonlinear system · Temperature

83.1 Introduction

Facilities agriculture becomes the most important modern agricultural development one of the ways so that more and more attention has been paid to people in the world. Facilities agriculture takes some measures to improve environment conditions which are not suitable for crop growth, such as computer and automation technology. To realize the continuous production, overcoming traditional agriculture is difficult to solve the limiting factor, for instance the natural climate restrictions, agricultural production regional restrictions and so on. In a certain temperature range of crops photosynthetic rate and temperature are positively related, namely the higher the temperature, the crop of photosynthesis rate faster. The air humidity is mainly refers to the relative humidity of air in a greenhouse. Relative humidity is that on condition that temperature and humidity remains the

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constant, the proportions of wet air pressure and saturated steam pressure. When temperature is different state, saturated steam pressure is different state. Even if saturated steam pressure remains invariant in the same two cases, relative humidity of different temperature is different state. With the influence of crops transpiration, the air relative humidity directly affects the crop growth and the occurrence of crop diseases (Wang et al. 2008).

The change of the temperature and humidity has very obvious periodicity and follow the law of greenhouse control. The change of the temperature and humidity always remain opposite direction. When the temperature increases, humidity decreases. When the humidity increases, the temperature decreases. Humidity rates of change are obviously greater than temperature. Humidity changes always slightly lags behind the change of the temperature. To control the temperature and humidity will affect another factor of change. On the other hand, actuator action also affects not just a factor. Greenhouse environment factors in the coupling relationship between temperature and humidity, it is difficult to solve the problem of the coupling of between temperature and humidity (Deng 2004).

83.2 The Model of Temperature and Humidity in the Greenhouse Environment

Generally speaking, the main control goals are indoor variable which can be directly measure. Consequently, indoor variables are regarded as state variables. The effect of parameters of indoor main is outdoor variables. Outdoor variables which have the very strong random can measure but can't control so we could be considered as disturbance variable. According to related references, the model of temperature and humidity in the greenhouse environment is summarized as following (Deng 2004; Isadora 1995):

$$\rho C_p h \frac{dT_i}{dt} = \frac{A_p h_p}{A_f}(T_p - T_i) - \left(\frac{\rho C_p G}{A_f} + \frac{\beta_1}{2}\right)(T_i - T_o) - \frac{e_{s25}\beta_2}{\gamma} T_i + \frac{h_1 B}{8.036\gamma} w_i + (\tau\alpha_1 F_1 F_2 - 0.55 C_i) H_1 \tag{83.1}$$

$$\rho h \frac{dw_i}{dt} = \frac{0.55 C_i}{\lambda} H_1 + \frac{e_{s25}\beta_2}{\lambda\gamma} T_i - \frac{B}{8.0368\gamma\lambda}\left(h_1 + \frac{\rho C_p G}{A_f} + h_{cond}\right) w_1 + \frac{\rho C_p G B}{8.036\gamma\lambda A_f} w_{out} - \frac{A_p h_p}{A_f \lambda}(T_p - T_i) + \frac{h_{cond}}{\gamma\lambda} e_c \tag{83.2}$$

Among them:

A_p Heating pipe surface area (m^2);
G The rate of air ventilation ($m^3 \cdot h^{-1}$);
C_p Air heat capacity ($KJ \cdot kg^{-1} \cdot K^{-1}$), 0, 1.012;
Ct Empirical constant (–), 0.1–10;
e_c Saturation point of Water vapor pressure (Pa);
A_f Area of greenhouse (m^2);
e_{s25} When indoor temperature is 25 °C, saturated water vapor pressure is e_{s25} (Pa);
B Atm press (Pa);
F_1 Reflection coefficient of capping mass;
h_1 When sunshading board started, height of sublayer is h_1 (m);
F_2 The conversion coefficient of plant photosynthesis and soil ground storage of solar radiation, 0.1–1;
h_p Hot water pipe heat transfer coefficient ($W \cdot m^2 \cdot k^1$), 1–10;
h The average height of greenhouse (m);
h_{cond} Coefficient of heat conduction of air and palisade structure ($W \cdot m^2 \cdot k^1$), 1–10;
H_1 Outside the sun radiation degrees ($W \cdot m^{-2}$);
τ The sun's average transmission rate of capping mass;
T_o Outdoor temperature (K):
T_i Indoor temperature (K);
T_p Heating pipe temperature (K);
W_i The ratio of water and air ($kg\,[water] \cdot kg^{-1}\,[dry \quad air]$);
ρ Air mass density ($kg \cdot m^{-3}$);
W_{out} Ratio of greenhouse external water and air ($kg\,[water] \cdot kg^{-1}\,[dry \quad air]$);
λ Latent heat of evaporation of water ($kJ \cdot kg^{-1}$);
β Temperature changes saturated steam pressure on the comprehensive coefficient;
γ Relative humidity unchanged, the water vapor pressure changes with the temperature of the slope (–).

Model contains two inputs: T_p and G;
Output is T_i and w_i;
Disturbance variables are H_i, T_o and w_{out}.
System of the variables are observed.
Order:

$$a_1 = \frac{-\left(\frac{A_p h_p}{A_f} + \frac{\beta_1}{2} + \frac{e_{s25}\beta_2}{\gamma}\right)}{\rho C_p h};$$
$$a_2 = \frac{h_1 B}{8.036\gamma\rho C_p h};\ \ a_3 = \frac{A_p h_p}{A_f \rho C_p h};\ \ a_4 = \frac{1}{A_f h};$$
$$a_5 = \tau\alpha_1 F_1 F_2 - 0.55C_1;\ a_6 = \frac{\beta_1}{2};$$
$$b_1 = \frac{\frac{e_{s25}\beta_2}{\lambda\gamma} + \frac{A_p h_p}{A_f \lambda}}{\rho h};\ b_2 = \frac{\frac{-B(h_1 + h_{cond})}{8.0368\gamma\lambda}}{\rho h};\ b_3 = -\frac{A_p h_p}{A_f \lambda\rho h};$$
$$b_4 = \frac{BC_p}{8.0368\gamma\lambda A_f h};\ b_5 = \frac{0.55C_1}{\lambda\rho h};\ b_6 = \frac{h_{cond} e_c}{\gamma\lambda\rho h}.$$

Model can be expressed as following:

$$\begin{aligned}\dot{x}_1 &= a_1 x_1 + a_2 x_2 + a_5 v_1 + a_6 v_2 + a_3 u_1 + (a_4 x_1 + a_4 v_2)u_2 \\ \dot{x}_2 &= b_1 x_1 + b_2 x_2 + b_5 v_1 + b_6 + b_3 u_1 + (b_4 x_2 + b_4 v_3)u_2\end{aligned} \tag{83.3}$$

Apparently, this is a nonlinear system (He and Yan 2007; Hu 2002).

83.3 Globally Progressive Tracking Control

We want to change temperature and humidity of crop into ideal values, so we can choose output variables as following:

$$\begin{aligned}y_1 &= h_1(x) = x_1 \\ y_2 &= h_2(x) = x_2\end{aligned} \tag{83.4}$$

Ideal output:

$$y_d = \begin{pmatrix} y_d^1 \\ y_d^2 \end{pmatrix} \tag{83.5}$$

Among them, x_1 means the current greenhouse temperature, y_1 means the current greenhouse output temperature, y_d^1 means target temperature, x_2 means the current greenhouse humidity, y_2 means the current greenhouse output humidity, y_d^2 means ideal humidity.

Now the problem of control can be expressed as following: for (83.3) and (83.4), we can choose $u = \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} = \begin{bmatrix} T_p \\ G \end{bmatrix}$, and make our output vector track ideal temperature and humidity (83.5).

We can make (83.3) rewrite as following:

$$\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \end{pmatrix} = \begin{pmatrix} f_1 \\ f_2 \end{pmatrix} + \begin{pmatrix} g_1 & g_2 \end{pmatrix} \begin{pmatrix} u_1 \\ u_2 \end{pmatrix} \tag{83.6}$$

then:

$$\begin{aligned} f_1 &= a_1x_1 + a_2x_2 + a_5v_1 + a_6v_2; \;\; f_2 = b_1x_1 + b_2x_2 + b_5v_1; \\ g_1 &= \begin{bmatrix} a_3 \\ b_3 \end{bmatrix}; \;\; g_2 = \begin{bmatrix} a_4x_1 + a_4v_2 \\ b_3x_2 + b_4v_3 \end{bmatrix}. \end{aligned}$$

It then calculates lee derivative and relative order (He and Yan 2007; Hu 2002). $L_f^0 h_1(x) = h_1 \neq 0$, $r_1 = 1$, relative order is 1.

$$\begin{aligned} L_{g_1}L_f^0 h_1 &= \begin{pmatrix} \frac{\partial h_1}{\partial x_1} & \frac{\partial h_1}{\partial x_2} \end{pmatrix} g_1 = \begin{pmatrix} 1 & 0 \end{pmatrix} \begin{pmatrix} a_3 \\ b_3 \end{pmatrix} = a_3 \\ L_{g_2}L_f^0 h_1 &= \begin{pmatrix} \frac{\partial h_1}{\partial x_1} & \frac{\partial h_1}{\partial x_2} \end{pmatrix} g_2 = \begin{pmatrix} 1 & 0 \end{pmatrix} \begin{pmatrix} a_4x_1 + a_4v_2 \\ b_4x_2 + b_4v_3 \end{pmatrix} = a_4x_1 + a_4v_2 \\ L_{g1}L_f^0 h_2 &= \begin{pmatrix} \frac{\partial h_2}{\partial x_1} & \frac{\partial h_2}{\partial x_2} \end{pmatrix} g_1 = \begin{pmatrix} 0 & 1 \end{pmatrix} \begin{pmatrix} a_3 \\ b_3 \end{pmatrix} = b_3 \\ L_{g_2}L_f^0 h_2 &= \begin{pmatrix} \frac{\partial h_2}{\partial x_1} & \frac{\partial h_2}{\partial x_2} \end{pmatrix} g_2 = \begin{pmatrix} 0 & 1 \end{pmatrix} \begin{pmatrix} a_4x_1 + a_4v_2 \\ b_4x_2 + b_4v_3 \end{pmatrix} = b_4x_2 + b_4v_3 \end{aligned}$$

Then

$$A(x) = \begin{bmatrix} a_3 & a_4x_1 + a_4v_2 \\ b_3 & b_4x_2 + b_4v_3 \end{bmatrix} = G(x) \tag{83.7}$$

According to nonlinear feedback linearization theory (Isadora 1995), if $|A(x)| = (a_3b_4x_2 + a_3b_4v_3 - a_4b_3x_1 - a_4b_3v_2) \neq 0$ (usually situation, the value of the matrix to zero), $A(x)$ is invertible matrix (Hu 2002; Deng et al. 2005). Then the system can utilize state feedback:

$$u = A(x)^{-1}(-f(x) + \Delta) \tag{83.8}$$

linearization:

$$\dot{x} = \Delta \tag{83.9}$$

Among them Δ is unknown vector so as to achieve the purpose of gradual tracking. According to gradual tracking control method, we can choose Δ to realize system of decoupling and linearization.

Now we will make the system realize tracking control (Bloch et al. 1993).

We can make $e = \begin{bmatrix} e_1 \\ e_2 \end{bmatrix}$ express system error:

$$e = y - y_d = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} - \begin{bmatrix} y_d^1 \\ y_d^2 \end{bmatrix} \tag{83.10}$$

In order to make $\lim e(t) = 0$ come true, we can design $R = \begin{pmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{pmatrix}$ which can make matrix eigenvalues have negative real part. Namely the solution of the $\dot{e} = \mathrm{Re}$ satisfy $\lim e(t) = 0$. Eigenvalues of the matrix $R = \begin{pmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{pmatrix}$ have negative real part.

Then equation:

$(\dot{x} - \dot{y}_d) + \begin{pmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{pmatrix}(x - y_d) = 0$ the answer of the equation satisfy:

$$\lim(x_1(t) - y_d^1) = 0$$
$$\lim(x_2(t) - y_d^2) = 0$$

If we have designed matrix $R = \begin{pmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{pmatrix}$, we can substitute $\dot{x} = \Delta = \begin{pmatrix} \Delta_1 \\ \Delta_2 \end{pmatrix}$ for $(\dot{x} - \dot{y}_d) + \begin{pmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{pmatrix}(x - y_d) = 0$

Then:

$$\begin{pmatrix} \Delta_1 \\ \Delta_2 \end{pmatrix} = \begin{pmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{pmatrix}\begin{pmatrix} x_1 - y_d^1 \\ x_2 - y_d^2 \end{pmatrix} + \begin{pmatrix} \dot{y}_d^1 \\ \dot{y}_d^2 \end{pmatrix}.$$

According to $u = A(x)^{-1}(-f(x) + \Delta)$, we can gain (Bortoff 1992):

$$\begin{pmatrix} u_1 \\ u_2 \end{pmatrix} = A(x)^{-1}\left(-f(x) + \begin{pmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{pmatrix}\begin{pmatrix} x_1 - y_d^1 \\ x_2 - y_d^2 \end{pmatrix} + \begin{pmatrix} \dot{y}_d^1 \\ \dot{y}_d^2 \end{pmatrix}\right)$$

Closed loop system:

$$\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \end{pmatrix} = \begin{pmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{pmatrix}\begin{pmatrix} x_1 - y_d^1 \\ x_2 - y_d^2 \end{pmatrix} + \begin{pmatrix} \dot{y}_d^1 \\ \dot{y}_d^2 \end{pmatrix}$$

Namely:

$$\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \end{pmatrix} = \begin{pmatrix} r_{11}(x_1 - y_d^1) + r_{12}(x_2 - y_d^2) + \dot{y}_d^1 \\ r_{21}(x_1 - y_d^1) + r_{22}(x_2 - y_d^2) + \dot{y}_d^2 \end{pmatrix}$$

Then:

$$\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \end{pmatrix} = \begin{pmatrix} r_{11}x_1 + r_{12}x_2 - r_{12}y_d^2 - r_{11}y_d^1 + \dot{y}_d^1 \\ r_{21}x_1 + r_{22}x_2 - r_{21}y_d^1 - r_{22}y_d^2 + \dot{y}_d^2 \end{pmatrix} \tag{83.11}$$

It has made the system output variables track ideal value (Byrnes and Isidori 1991; Isidori 1995).

83.4 Simulation

According to $\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \end{pmatrix} = \begin{pmatrix} r_{11}x_1 + r_{12}x_2 - r_{12}y_d^2 - r_{11}y_d^1 + \dot{y}_d^1 \\ r_{21}x_1 + r_{22}x_2 - r_{21}y_d^1 - r_{22}y_d^2 + \dot{y}_d^2 \end{pmatrix}$, we should choose proper matrix $R = \begin{pmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{pmatrix}$ and make it have negative real part. Consequently, we can make the solution of the $\dot{e} = \text{Re}$ satisfy $\lim e(t) = 0$.

For this, we can choose matrix

$$R = \begin{pmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{pmatrix} = \begin{pmatrix} -5 & 0 \\ 0 & -6. \end{pmatrix}$$

For example, we can satisfy the needs of growing tomatoes in the greenhouse. The crops in a day of different period of temperature and humidity requirement is not only changing, but also the growth in different periods of temperature and humidity on the specific requirements of the also have the difference. In order to simplify the problems at the same time, to verify the purpose of the performance of the system, we can first set in a certain period a day (24 h) of tomatoes in the growth of the optimum temperature and humidity objective function, and make simulation prove systems tracking performance (Hermann et al. 1983).

83.5 Parameter Selection

In view of the optimum temperature and humidity selection, we can draw a conclusion as following:

During the day, according to the requirements of the best crop growth and the light intensity changes, we can set the optimal temperature parameters to maximize the photosynthetic rate to maximize realized the accumulation of organic compounds.

In the night, on condition that we can meet the basic conditions to grow crops, we try to reduce the temperature value. Like this method also is able to achieve the goal of saving energy (Table 83.1).

By Shenyang area sunshine the characteristics of the environment, we can regard the morning at 6:00 as a research time starting point and selected the results period as a target of the crop of the study period. To compare with other period, the highest temperature requirements are demanded by crops in the results period. This kind of situation can cause fruit rate drop if temperature can not reach the requirements. On the other hand, for tomatoes, during the day the material of assimilation will operate. In the night, a few substances could be remained so we need to reduce the temperature at night as early as possible (Hale 1980; Ly and Canny 1993).

Table 83.1 Temperature and humidity of tomato growth target value in the result period

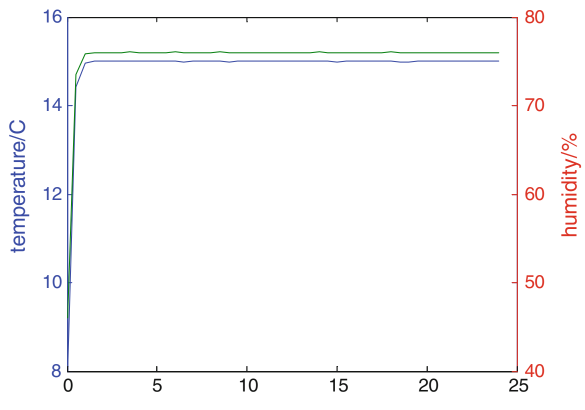
Time	Temperature setpoint	Relative humidity of the air settings	Time	Temperature setpoint	Relative humidity of the air settings
6.00	16	80	16.00	27	40
6.30	19	75	17.00	26	48
7.00	21	70	19.00	25	70
7.30	23	62	19.30	24	85
8.00	25	57	20.00	24	84
8.30	26	50	21.00	23	82
9.00	27	45	22.00	23	87
9.30	28	42	23.00	22	86
10.00	29	38	0.00	21	83
12.00	30	28	1.00	20	80
13.00	29	26	2.00	19	82
14.00	28.5	28	3.00	18	86
15.00	27.5	32	5.00	17	88
15.30	27.3	35			

83.6 Simulation Results and Analysis Set Constant Tracking

Indoor the current environment initial value is $x_1 = 8,\ x_2 = 0.46$, x_1: the current air temperature is 8 °C; x_2: the current air relative humidity is 36 %, target value is $y_d^1 = 20, y_d^2 = 0.76$; y_d^1: ideal air temperature value is 20 °C, y_d^2: ideal air relative humidity value is 76 %.

We can make abscissa represent time (t/h). As can be seen from the Fig. 83.1, system static tracking characteristics meet the control requirements.

Fig. 83.1 Set constant tracking



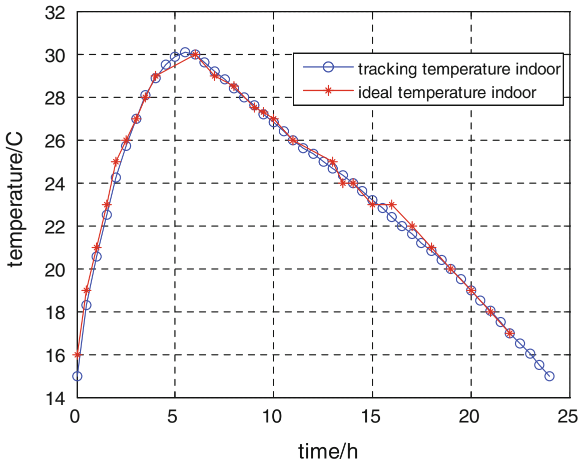


Fig. 83.2 Dynamic tracking temperature curve

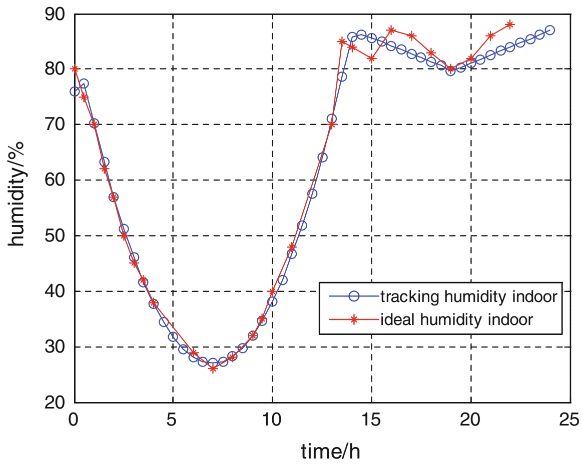


Fig. 83.3 Dynamic tracking humidity curve humidity tracking curve

83.6.1 Dynamic Tracking Characteristics

The initial value of system can be set $x_1 = 15$, $x_2 = 0.76$. x_1: The current air temperature is 15 °C, x_2: The current air relative humidity is 76 %. As can be seen from Figs. 83.2 and 83.3, we can make the tomatoes temperature and humidity need of result period set dynamic target value.

83.6.2 Curve of Tracking System

As can be seen from Fig. 83.1, we find the temperature and humidity in the greenhouse reach the target value in one hour.

We can see, in different temperature, humidity initial value the system can realize to track quickly the output target value. Dramatic changes in individual point, the system will be able to realize the stable tracking.

83.7 Conclusion

This paper applied in nonlinear system accurate linearization and gradual tracking method to solve the temperature, and humidity control system. We can make temperature and humidity become output variables, calculate the relative order of system, and design feedback linearization and gradual tracking control. To Set the static and dynamic two objective function way, we can see that the closed-loop system to quicker response speed realize to track and regulate greenhouses system (Cook 1989; Baumann and Rugh 1986).

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Chapter 84
The Application of Six Sigma Management in Product Service System

Zongjun Lv, Rui Miao and Shen Wang

Abstract Based on the methodology and tools of six sigma managements, this paper mainly focuses on an automobile steel plate-shearing line, which can be regarded on as a product service system since the supplier of machines provides service after sales. And the result proves that the machining accuracy of product has been improved obviously. It not only shows that six sigma is very effective concept and methodology in manufacturing industry, but also can be learned lesson from and has an important popular significance for more and more product service systems to improve the process control and product quality.

Keywords Accuracy of product · Product service system · Quality control · Six sigma management

84.1 Introduction

Six sigma management is regarded as one kind of advanced concept and methodology on quality management system. It can efficiently improve the product quality and manufacturing. In recent years, six sigma management has aroused widespread attention as an advanced management method, and been applied successfully in many domestic and foreign major industries. Tao (2010) discussed that the differences between the six sigma quality management and the other

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quality management approaches is the four core characteristics. Yang and Gao (2010) and Yan and Kong (2010) had made a concise description of the background of Six Sigma approach, and analyzed its statistics meaning and theoretic thought. Yu et al. (2010) studied how to optimize product design process and realize design quality innovation on actual product through six sigma design. Shi et al. (2010) revealed the necessary conditions that the small and medium-sized enterprises implement the six sigma management. Liu (2005) introduced ISO9000 certification and six sigma management, and mainly elaborated effect about ISO9000 certification and six sigma management in corporation. Huang (2008) put forward countermeasures against some problems in the implementation of six-δ management. Yu et al. (2006) brought six sigma into process management of engineering project. Based on the discussion of the essence and connotation of six sigma. Wang et al. (2007) put forward some feasible measures to improve the examination quality of university and college in China. He et al. (2007) pointed out the key role of executive management in six sigma implementation from business system perspective and he presented six sigma implementation roadmap and addressed key issues in the implementing process. Xia (2009) analyzed the significance of 6σ in constructing the model of library service remedy system. Zhang (2005) introduced the history of 6σ management system and its springing up trend in the world wide. Liu (2006) simply introduces six sigma management, mainly elaborates how to inter into effect by six sigma management from cost of poor quality timely about corporation. Cheng Shi applied quality management theory six sigma in equipment quality management. Zhao and Chen (2007) pointed out that good department of construction manager, qualified project manager, scientific management method for schedule, cost and quality control are critical assurances to realize anticipated engineering objectives.

Based on the methodology and tools of six sigma management, this paper mainly focuses on a product service system. The result proves that the machining accuracy of product has been improved obviously.

The automobile steel plate-shearing product service system was put into operation in 2002, whose equipment imported from Germany, and mainly produced the automobile plates. It can cut into the plate in dimension according to the consumer's requirements, with side trimming, oiling, improving shape, surface inspection. Its main equipment were consisted of side trimmer (width of cutting edge), straightening machine (improving shape), flying shear (length shearing), the oiler (preventing corrosion), stacking machine (steel plate stacking). The design capacity of the line is 309,300 tons per year, whose customers included GM, Volkswagen, Nissan, Ford and other domestic and foreign automobile manufacturers. The production process is incoming inspection, uncoiling, CPC, side trimming, thickness measurement, straightening, length shearing, surface inspection, oiling, stacking, packaging.

In recent years with the automobile market and home appliances market sales remained hot, the quality of product service system could not meet the market users and the internal requirements. The size of system is in a poor accuracy. It not only created resources waste for enterprises, but also caused complaints from consumers. Therefore, tools of six sigma management are very necessary to be used to improve product quality, meet the requirements of company and market demand, as well as to raise the performance of enterprises and market competitiveness of the enterprise.

84.2 Methodology

84.2.1 Definition Phase

First a project team should be set up, included black belt, black belt master, green belt and process experts and other members. Then project goals and targets should be defined (see Table 84.1). And the problems and opportunities for improvement were described. The application of SIPOC on the project involves the product service system in the related links for process analysis, and defined the scope of business. At the same time, the key requirements of customers must be recognized and should be transformed into key business requirements.

The process decomposition was carried out in the project starting meeting. Width of product service system could be decomposed into cutter, parameter adjustment, screw adjustment, rack locking, rotating cutting edges, measuring check, while length of shearing flow decomposition into the length of signal measurement, signal transmission, PLC information processing, PLC output control signal, motor rotation, shear movement, measuring length.

In trimming process analysis, found that the tool carriers had almost no movement, i.e. the width of the strip would have no big fluctuation, on the basis of copper nut and ball screw, coupled with the locking tool if the left and the right tool maintained a certain distance through the adjusting screw rod. Actually strip actual width depended on the regulating screw rod and the distance between the left and right tool. Operators always set the width in upper limit according to the plan form tolerance range, which resulted in the current fluctuations and large deviation. If the width setting could be standardized, that is in accordance with the provisions of the 0–2 mm range. It launched a pilot implementation, and had obvious effects. So seizing the opportunity existed as soon as possible, and improving the length shearing precision was the key problem to be undertaken.

Table 84.1 Project target

Index	Current level (%)	Optimal level (%)	Target (%)
Length of shear yield	30.20	100	75
Width shear yield	70.30	100	90

84.2.2 Measuring Phase

Twenty three related factors had been initially identified after the IPO index analysis of the decompounded input, process and output indicators. And cause matrix diagram should be made (see Table 84.2).

According to the cause and effect matrix diagram, some strong correlation causes like the length width value setting, incoming oil or not, the pulse generator precision and hydraulic drive motor precision were initially selected. At the same time data collection plan was made, and process stability was analyzed. In addition, current measurement system should be analyzed through the Gage R&R and ANOVA tools (person and tool). The value of R&R was 14.84 %. The measurement system can be accepted, considering the contract tolerance range is more than 1 mm. And the current level of sigma is 0.843σ according to the sample calculations.

Table 84.2 Cause matrix diagram

Important to the customer over the weights (1–10 grade)		9	
Main output value		Actual length of steel plate	
Process step	All input values	Correlation coefficient	Total
Length of signal measurement	Flatness status	1	9
	Incoming materials	1	9
	Length value	9	81
	Oiled or not	9	81
	Set tension	1	9
	Line speed	1	9
	Measurement of wheel diameter	3	27
	Measuring wheel pressure	3	27
	Accuracy of pulse generator	9	81
	Roundness of measurement wheel	1	9
Signal transmission	Photoelectric conversion accuracy	3	27
	The plug loose	3	27
PLC signal processing	CPU operation speed	1	9
The output control signal	Signal level precision	1	9
The rotation of the motor	Hydraulic drive motor control precision	3	27
	Hydraulic drive motor precision	9	81
	AC motor response accuracy	1	9
	Additional acceleration torque	1	9
	DC motor response accuracy	1	9
The movement of the Shear	Shear bit (copying switch)	3	27
	The upper and lower blades overlap and side clearance	3	27
Measuring	Measurement of frequency	0	0
	Tape ruler precision	0	0

Note 0, 1, 3, 9 respectively represented no correlation, weak, medium, strong correlation

84.2.3 Analysis Phase

Dimensions accuracy unqualified reasons were analyzed with the process of stratification and Cause and Effect Diagram (or called fishbone diagram) (See Fig. 84.1).

On the basis of Cause and Effect Diagram, QFD matrix (Function Deployment Matrix) was made. And the function type is Y (eccentric flying shear length yield) = f(X). In which, X was initial computer setting value, including materials surface oiling, length measuring wheel pressure, measuring wheel installation, encoder accuracy, measuring wheel input supplementary coefficient and flying shear zero. Here we took the correlation regression analysis for example. A computational result shows that the P value is 0, less than 0.05, and gives the initial set value and the actual length of the function equation.

The measured value = set value + 1.4.

Similarly, paired T test were used to test incoming surface oil. The length measuring wheel pressure correlations were analyzed. The measuring wheel installation and the straightness of the flying shear's zero setting were compared with the experiments. The encoder accuracy was analyzed by 1-Sample Wilcoxon. And measuring wheel input complement coefficient was test by T test.

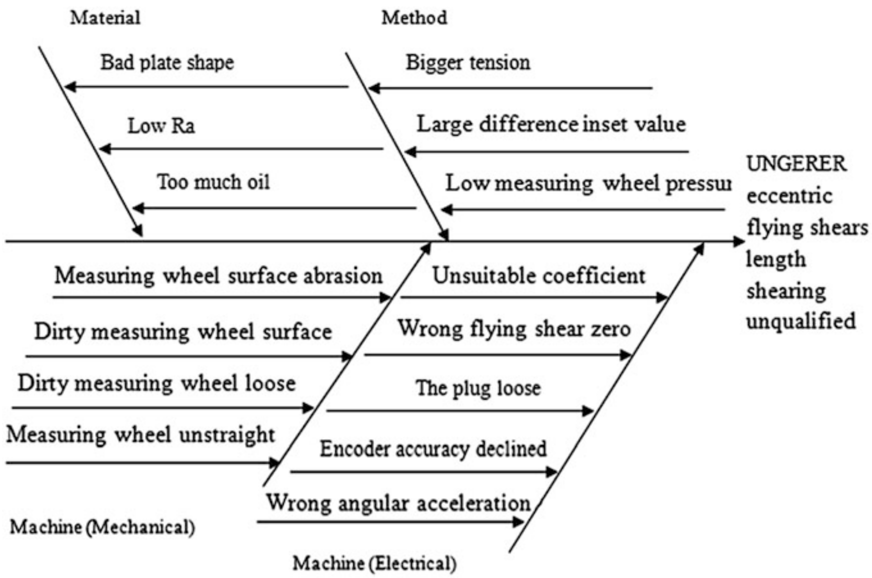

Fig. 84.1 Cause and effect diagram

Table 84.3 Program quantitative evaluation table

Solution	Sigma effect	Time effect	Cost effect	Total	Choose or not
Set based on to the contract. 1 mm bigger when double length	7	10	8	79	Y
Cleaning or modified material of the measurement of wheel surface	4	10	6	67	Y
Set based on the material oil or not	4	10	6	67	Y
Check the installation according to copy paper's visual effect every time	7	10	8	85	Y
Input the diameter and correction according to abrasion every time	4	10	6	67	Y
Check the zero position with visual identification	1	10	2	49	N
Input the diameter and correction according to abrasion every time	4	10	6	67	Y
Check the zero position with visual identification	1	10	2	49	N

84.2.4 Improvement Phase

In view of the above reasons, 19 plans were to come into beings through Brain Storming, and seven of which were confirmed after initial evaluation. A good improvement scheme is not able to give the customer or the enterprise brings high risk cost. Therefore, it is necessary to assess effects of objective, time, cost and benefits (see Table 84.3).

Subsequent to select scheme further refinement, and make project Gantt chart.

84.2.5 Control Phase

After the implementation of the pilot it extended in four classes. Statistical Process Control diagram was established based on the MINITAB software Control Charts module. It showed that the shearing yield had been greatly increased, from 70.3 to 93.2 %. And the improvement of length and width of cutting precision can respectively make 0.92 and 0.32 million Yuan, and can make a total of 1.24 million Yuan annual benefit.

84.3 Conclusion

In this paper, the application of six sigma methodology and tools to product service system of a company in quality control was implemented. The production process quality control had been improved, and the ways were put into standardization and a new PDCA closed loop. In the manufacturing industry by using six sigma management method is very effective, and it has an important significance for product service system to improve the process control and product quality.

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Chapter 85
The Detection Device for Large Diameter Roll's Quality and the Design of System

Hu-ji Leng, Hao Wang and Guo-ping Fan

Abstract Based on on-line detection technology of computer, combined with process control theory, the roll diameter detection process quality control system is designed; meanwhile the roll diameter automatic detection, data acquisition, analysis, process as well as statistical process control of the process is realized. For the part of software, adopting the theory of statistical process control, the software employs JSP procedure code to designing system, so as to realize automatically collect database data of process quality control system, on-line analysis control of computer and process function for abnormal. For the part of hardware, the roll automatic detection device is researched and designed. Adopting Minitab software and the research data are applied to analyze the measurement system, thereby to verify the reliability, thus that measurement system meets measurement standard can be determined, through on-line analysis to determine the accuracy of the monitoring system. The result shows that the designed automatic detection system has good accuracy and reliability.

Keywords Automatic detection · Measurement system analysis · Process quality control system · Statistical process control

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85.1 Introduction

On the basis of the process quality control level is still backward in China, thus lead to the problem of the poor of products quality of production and waste defect rate remains high, roll's diameter size will affect the precision directly which it cannot meet the requirement, proposed the roll diameter process as the research object in a steel, based on automation testing, computer technology, combined with process quality control theory (include non-contact sensor technology and data collection technology) (Yu 2002; Yu and Zhang 1999), the roll diameter quality detection software system is designed, the system will complete the automation detection of the roll diameter firstly, then acquire the detection information into the database, through the application, adopting the statistical quality control tool of the control chart and process capability index, it will realize the quality control of the accuracy of roll diameter.

85.2 Methodology

85.2.1 Research Content of Thesis

The main research content of this topic includes the following aspects:

(1) Analyze the detection level and the problem of roll diameter in a steel factory through the investigation.
(2) Obtain the system function according to the analysis of system requirements and design the whole framework layout of system.
(3) Design system hardware: the choice of detector and the development and instruction of detection device, so as to raise the detection level of roll diameter, it can reduce the labor load, and referent the PDCA cycle and QC group to the detection of roll diameter, forming continuous improvement ideas and put it into practice.
(4) Design system software: employs JSP procedure code to designing system, collect automatically the detection data of roll diameter, analyze process quality control with Minitab software (Liu and Fu 2011; Li and Zhao 2001).
(5) Instruct system function: analyze the detection data of roll diameter with measurement system and print reports, find reason of the abnormal situation and take measures to eliminate it, realize process control and raise the image of enterprise.

85.2.2 Process Quality Control Theory

On the basis of "product inspection" which process quality control developing. The application means of "product inspection" is various types of measurement tools and instruments, the method is checking strictly (Tang et al. 2004). Modern process quality control brings into the mathematical statistics method (Qin et al. 2005; Li 2005); it not only overcomes the disadvantages of after inspection, but also the support of computer technology and automatic detection technology, it can realize the monitoring and warning of the production process, the raising problem which feedback analysis timely and try to solve it.

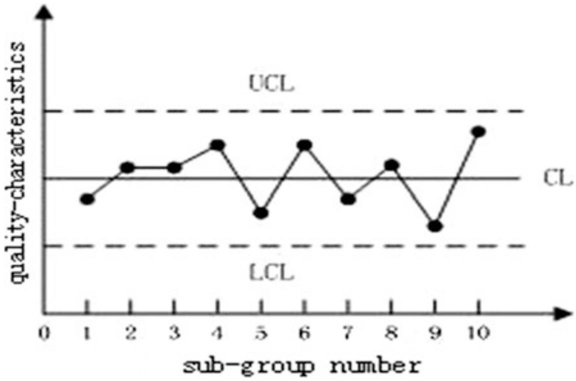
After bringing into the mathematical statistical technology, process quality statistical process control becomes process quality control means of most and broadest of enterprise application. In the process of product production, monitoring the change and regular of process quality factors with probability and mathematical statistics theory, so that the quality feature values of product vary from lower control limit to upper control limit, the purpose is producing the product of customer satisfaction (Liu 1996). The theoretical basis of statistical process control is the view of product quality statistics (Han 2004), it includes the fluctuation, reason analysis of product quality concretely and fluctuation regular of product quality feature values.

85.2.3 Statistical Process Control Theory

Control chart is a record diagram which monitoring process is whether controlled or not, used to access and record process quality feature values (Zhang and Sun 2002). Control chart is proposed by W. A. Shewhart of United States in 1924.

Control chart is a tool, control chart can analyze process is whether steady state or not, it also can guarantee quality capability. Through the analysis of control chart, it also obtains the information which some links need to be improved in the production process. Center line and fluctuation control limit is calculate statistically by a set of data that is collected in process improvement, people can't assume without authorization, only in this way can we effectively reveals the status of the process is stable or isn't stable, otherwise they will lose the significance of analysis and monitoring (Fig. 85.1).

Fig. 85.1 Control chart



85.3 Results

85.3.1 Design Detection Device

This topic is take RBL038-385-02Z as research object, the roll body's diameter of this specification is very large, the total length is 3850 mm, the basic size of roll body's diameter is 380 mm, so it can set the appearance size of laser caliper gauge according to the detailed size of drawings, measuring range can set 400 mm.

In order to realize the automatic detection of roll for large diameter which design measurement device of Fig. 85.2, the measurement device is composed of side platens, laser caliper gauge and V type stents, side platens and laser caliper gauge have been fixed together, installed in a side of the machine tool, it can moves with laser caliper gauge. Laser caliper gauge which located in both sides of the side platens, if measurement, put the detection roll in the V type groove, the motor installed in one side of machine tool, the pulley drive the ball screw of machine tool, the ball screw drive the laser caliper gauge of side platens, they move back and force in the machine tool, laser caliper gauge center and roll diameter center hold unified height level, so that meet the measurement requirements, while laser caliper gauge center pass the roll, both sides of laser caliper

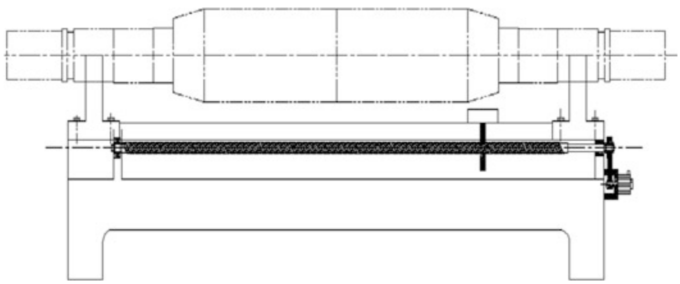


Fig. 85.2 Detection device schematic diagram

gauge scanning respectively both sides of the different parts of the roll, thus obtain the diameter data and fulfill measurement. When measuring different models of roll diameter, we can adjust the position of laser caliper gauge to meet the measurement requirements (Liu and Liu 2007; Ma 2008).

85.3.2 Design the Software Detection System

Detection device complete automatic detection of roll diameter, testing instrument established a connection through serial communication and computer application, it will realize data acquisition and statistical analysis and processing of the sequence. After requirement analysis, get the following instruction of the functional module of system software (Hou 2004; Liu 2003).

(1) Module of user management: add user name and password through the module.
(2) Module of product parameter: input the relative products quality parameter according to the specific requirements, put them into the database, we can browse, inquire, compile, and delete the data at any time.
(3) Module of data acquisition and display: read the detection data of the data acquisition instrument from the serial port of computer, put them into the database, and display in the friendly program interface.
(4) Module of process analysis: judge the process is whether statistical steady state and technology steady state or not with control chart and process capability index, if process is stable, record control limit of control chart, put them into the database, as the application of control limit of control chart (Fig. 85.3).

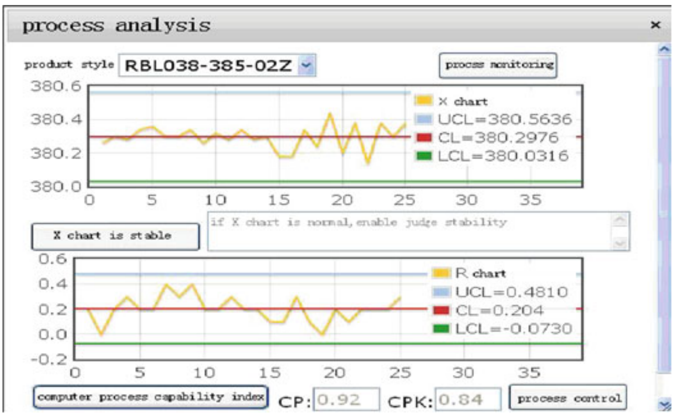


Fig. 85.3 Process analysis

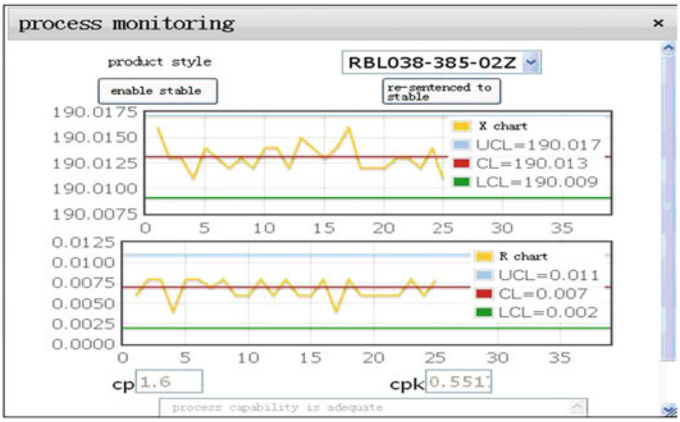


Fig. 85.4 Process monitoring

(5) Module of process monitoring: if process is steady state, display the detection results with the control chart of control application, and judge the process is whether steady state or not (Fig. 85.4). It can call directly control limit of control chart of analysis application (Long 2000).

(6) Module of system function: compile the data, control chart and analysis results and help operators at site.

85.4 Conclusion

In order to ascend status of international, the product quality has been more and more attended of the nation. The mode of traditional production is no longer adapt to the development of the times, the country and enterprise need to change the pattern urgently, the rapid development of information can solve these problems very well, in this situation the paper puts forward to the automatic detention technology and on-line analysis of computer technology, it will put statistical process control into production and improve the efficiency of enterprise very well, so the research of process quality control system has very important practical significance.

Acknowledgments Time flies, a three-year graduate student life is about to finish. After looking for hard work, I understand that the peace and thinking of writing the thesis. Looking back the graduate study course of several years, my heart is full of gratitude to people who guide, help and encourage me.

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Chapter 86
The Quality Control for Hydraulic Cylinder Based on QFD

Fu-ying Zhang, Hong-chao Zhang, Hui Zheng and Gang Chen

Abstract The customer requirements were obtained, packed up, and weighed through Scenario Analysis method, KJ method and AHP (Analytical Hierarchy Process) respectively. In order to translate the "voice of the customer" for hydraulic cylinder into the product design and manufacturing processes, the QFD (Quality Function Deployment) of hydraulic cylinder was built to translate the customer requirements into design speciation, subsequently into parts characteristics, manufacturing processes, and production quality requirements associated with its manufacture. By concentrating on resolving and eliminating the causes aroused quality problems and controlling the key quality characteristics of hydraulic cylinder, the hydraulic cylinder's quality can be made to meet customer requirements maximum.

Keywords House of quality · Hydraulic cylinder · Quality function deployment · Quality control

86.1 Introduction

Hydraulic cylinder is an actuator to carry out reciprocating moving while translating the hydraulic energy into mechanical ones. It was widely used in engineering machinery, mining machinery and metal cutting machine tools, because of its high trust, compact structure, and easy to maintain (Hua 2002). There is nothing

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new in a situation of equipment's shutdown, arose from the leakage and fault of hydraulic cylinder during its operating (Zeng et al. 2004). In order to decreases this situation, it is important to control the quality of hydraulic cylinder. QFD (Quality Function Deployment) (Partovi and Epperly 1999) originally developed and implemented in Japan at the Kobe Shipyards of Mitsubishi Heavy Industries is a systematic customer-drive quality management method. The central theme of this method is its identification of the voice of the customer and its translation into the product design and manufacturing processes (Temponi et al. 1999). The House of Quality (HoQ), which executes each translation, is of fundamental and strategy important (Ge et al. 2004).

QFD often uses four hierarchies of HoQ, which are called product planning HoQ, component deployment HoQ, process planning HoQ, and production planning HoQ respectively, to integrate the customer requirements, design specifications, part characteristics, manufacturing processes, and quality characteristic (Andreas et al. 2000). This method is widely used for product improving and quality assurance. It is a valid method for satisfying customer requirements, winning competition, increasing enterprise economic profits.

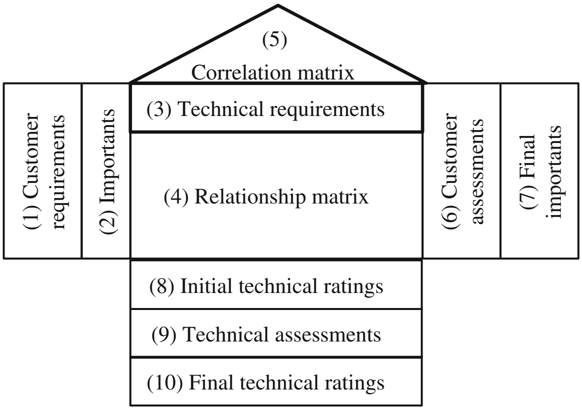
In this paper, we will first descript the HoQ. Then the product planning HoQ for hydraulic cylinder is built. Next the component deployment HoQ and process planning HoQ for hydraulic cylinder will be structured. Finally, the production planning HoQ sets process quality parameters, and the key quality characteristics associated with its manufacture are identified. By controlling these key quality characteristics, the parts standards and production quality requirements and customer requirements are ultimately met.

86.2 Description of HoQ

The HoQ of QFD is the effective tool for requirements translation. A full HoQ composes of ten matrixes (Zhang et al. 2009; Chen and Wu 2005) (Fig. 86.1).

The methodology begins with the customer's requirements (1) and the weights of importance of customer requirements (2). Product design characteristics (3) which satisfy the customer requirements are established relying primarily on the professional experience and intuition of a multidisciplinary team. Matrix (4) translates the customer requirements into measurable design requirements. The roof matrix (5) shows the interrelation among the design attributes, which is used as a constraint in limiting a particular design attribute. The customer's assessments matrix (6) provides the goals and opportunities. The final important of customer requirements in area (7) is calculated by customer relative important and customer competitive analysis matrix. The relative important of design requirement in (8) are computed using the absolute important of customer requirements and the relationship matrix. Matrix (9) consideration of cost trade-offs among design requirements. The weights of the technical requirement are placed at the matrix (10).

Fig. 86.1 House of quality



86.3 The Product Planning HoQ Building for Hydraulic Cylinder

86.3.1 The Customer Requirements Obtaining and Picking up for Hydraulic Cylinder

Through surveying, focus groups or interview, the voice of the customer were obtained. By using Scenario Analysis, the vague, ambiguous customer requirements are summarized and translated into the customer's quality requirements for hydraulic cylinder. These quality requirements are listed in Table 86.1.

86.3.2 The Customer Requirements Levels Analysis for Hydraulic Cylinder

The customer requirements can be further organized into different levels by using KJ method, a primary level for the most general requirements and secondary and tertiary levels for more detailed descriptions of the requirements. According to the customer requirements' level characteristic of hydraulic cylinder, the quality requirements of hydraulic cylinder are leveled by using KJ method, and list in Table 86.2.

Table 86.1 The quility requirements obtaining for hydraulic cylinder based on scenario analysis

Primary information	Scenario	Quality requirements
With high trust	Operating	The concern components should have enough strength and stiffness
		The oil pressure is higher
Can operate in a very bad environment		It can operate in a larger temperate range
With a high safety		It can work in the situation of shock and vibration
		It is safe and reliable when working
With a high stability		Position location is precise and the operating precision is higher
		There is little creep and flutter
Easy to maintain	Maintaining	It is easy to maintain
		The failure rate is lower
Compact structure	Assembling	The outline dimensions are smaller
		The weight is lighter
With lower working cost	Using	The service frequency is less
		The work efficiency is higher
Little leakage		The sealing performance is higher
Less pollution		There is little noise
Longer lifecycle		The concern components should have high wear resistance and corrosion resistance

TABLE 86.2 The levels of quility requirements for hydraulic cylinder

Primary levels	Secondary levels	Tertiary levels
Higher quality for hydraulic cylinder (QR)	Good dynamics (QR1)	Higher trust (QR11)
	Higher reliability (QR2)	Easy to maintain (QR21)
		Less service frequency (QR22)
		High wear resistance (QR23)
		Enough strength and stiffness (QR24)
	Good environment adaptability (QR3)	Operate in a very bad environment (QR31)
	Compact structure (QR4)	Smaller outline dimensions(QR41)
		Lighter weight (QR42)
	Good operating performance (QR5)	Little noise (QR51)
		High precise for position location and operating (QR52)
	Good economy(QR6)	Little leakage (QR61)

86.3.3 The Weights Calculating of Customer Requirements for Hydraulic Cylinder

AHP is a powerful and widely-used multi-criteria decision-making technique for prioritizing decision alternatives of interest Saaty (1990; Lu et al. 1994). In this paper, AHP is carried out to identify the relative weights of importance of the identified customer requirements.

According to the analysis steps of AHP (Armacost et al. 1994), the weights of importance of tertiary levels customer requirements of hydraulic cylinder are calculated as a vector of {0.089, 0.178, 0.033, 0.100, 0.058, 0.220, 0.059, 0.030, 0.032, 0.160, 0.014}.

86.3.4 The Product Planning HoQ Building for Hydraulic Cylinder

According to the description of HoQ, the product planning HoQ built for hydraulic cylinder is shown in Fig. 86.2. In this paper, the HoQ is simplex. It includes only seven matrixes such as customer requirements and its important, final important matrixes, the design requirements and its important matrixes, the relationships matrix between customer requirements and design requirements, the quality planning matrix, the other matrix are omitted.

The relationships matrix between customer requirements and design requirements judges which technical requirement impacts which customer requirement and up on what degree. The relationships can be assigned 0,1,3,5 to represent an unrelated, weak, medium, and strong relationship between customer requirements and technical requirements respectively (Park and Kim 1998). The quality planning matrix, through assessing the customer's perception of the competitive

Customer requirements / Design requirements	Important	Reasonable connect ways	Using exhaust member	Good sealing	Standard components	Buffer member	High Mechanical properties	High properties materials	Product company	Improvement goal	Improvement Ratio	Sales-Point	Final important(%)
Higher trust	8.9	3					3	5	3	3	1	1	5.17
Easy to maintain	17.8	1			5				4	5	1.25	1.5	19.37
Less service frequency	3.3		1	5		1			4	5	1.25	1.5	3.59
High wear resistance	10.0			5					3	3	1	1.2	6.97
Enough strength and stiffness	5.8	5					5	3	4	4	1	1	3.37
Operate in a very bad environment	22.0			5					3	5	1.67	1.5	31.98
Smaller outline dimensions	5.9	1						5	5	5	1	1.2	4.11
Lighter weight	3.0							5	4	4	1	1.2	2.09
Little noise	3.2	3	5			1			3	5	1.67	1.5	4.65
High precise for position location and operating	16.0		5			3	1	1	4	5	1.25	1.5	17.41
Little leakage	1.4			5		3	3		3	4	1.33	1.2	1.29
Technical ratings		69.79	113.89	219.15	96.85	64.34	53.64	84.37					

Fig. 86.2 The product planning HoQ for hydraulic cylinder

products, while taking into account for the factors such as sale, improving ratios, and customer requirements, provides the comprehensive weights of importance of customer requirements. The important of design requirements are computed as a vector of {69.79, 113.89, 219.15, 96.85, 64.34, 53.64, 84.37}, by using the final important of customer requirements and the relationship ranking.

86.4 The Building of Component Deployment and Process Planning HoQ

86.4.1 The Building of Component Deployment HoQ

The HoQ of component deployment focuses on the links between design specifications and part characteristics. In this HoQ, design characteristics and its important in the HoQ of product planning are as input for part characteristics deployment.

The HoQ of component deployment for hydraulic cylinder is shown in Fig. 86.3. After forming the relationship matrix between design requirements and part characteristics, the part characteristics important can be computed as before. From the result of computation, the key parts that with high effect to hydraulic cylinder design requirements can be identified.

86.4.2 The Building of Process Planning HoQ

The HoQ of process planning for hydraulic cylinder is shown in Fig. 86.4. The column headings from the component deployment matrix, along with their

Fig. 86.3 The component deployment HoQ for hydraulic cylinder

Design rrequirements	Parts / Technical ratings	Cylinder	Piston rod	Buffer valve	Guide sleeve	Sealing parts	Relative important (%)
High properties materials	69.79	◎	△	○			10.34
High Mechanical properties	113.89	◎		◎		△	16.87
Buffer member	219.15	△	△			◎	32.47
Standard components	69.85		△	△	○	◎	10.35
Good sealing	64.34	◎	○				9.53
Using exhaust member	53.64	◎	◎		◎		7.94
Reasonable connect ways	84.37	◎	○		○		12.50
Parts important	675.03	318.37	158.95	94.7	139.27	230.97	100

◎=5 strong relationship △=1 medium relationship ○=3 weak relationship

Parts \ Process characteristics	Parts important	Cylinder: The selection of material	Cylinder: Rough boring hole	Cylinder: Precision boring	Cylinder: Horning hole	Cylinder: Chromate treatment	Piston rod: The selection of material	Piston rod: Cylindrical rough turning	Piston rod: Cylindrical fine turning	Piston rod: Cutting slot	Piston rod: Cylindrical Horning	Piston rod: Chromate treatment	Buffer valve: The selection of material	Buffer valve: Cylindrical rough turning	Buffer valve: Cylindrical fine turning	Buffer valve: Screw thread	Guide sleeve: The selection of material	Guide sleeve: Cylindrical rough turning	Guide sleeve: Cylindrical fine turning	Guide sleeve: Cutting slot	Guide sleeve: Cylindrical Horning	Guide sleeve: Rough boring hole	Guide sleeve: Precision boring	Guide sleeve: Horning hole	Guide sleeve: Chromate treatment	Sealing parts: The selection of material	Sealing parts: Forming	Sealing parts: Triming	Sealing parts: Checking	Final important (%)
Cylinder	318.37	○	△	◎	◎	◎																								33.79
Piston rod	158.95						○	△	◎	◎	◎	◎																		16.87
Buffer valve	94.70												△	○	◎	○														10.06
Guide sleeve	139.27																○	△	◎	◎	◎	△	◎	◎	◎					14.78
Sealing parts	230.97																									◎	◎	○	○	24.51
Process characteristics ratings		101.37	33.79	168.95	168.95	168.95	50.61	16.87	84.35	84.35	84.35	84.35	10.06	30.18	50.3	30.18	44.34	14.78	73.9	73.9	73.9	14.78	73.9	73.9	73.9	122.55	122.55	73.53	73.53	100

◎=5 strong relationship △=1 medium relationship ○=3 weak relationship

Fig. 86.4 The process planning HoQ for hydraulic cylinder

respective importance values, are shifted over to become the rows of process planning matrix. The columns of this matrix are the process characteristics. The relationship matrix indicating the strength of relationships between part characteristics and process characteristics is organized using the same method as former relationship matrix. The outcome of these evaluations is a set of weights for process characteristics with respect to each part characteristics.

86.5 The Building of Quality Characteristic HoQ

86.5.1 The Building of Quality Characteristics HoQ

The objective of the quality characteristics HoQ in Fig. 86.5 is to identify the key production quality characteristics associated with manufacture. This HoQ relates the quality characteristics to the processing technology. As before, the columns of the process planning HoQ become the rows of this HoQ. The columns of this HoQ are the quality characteristics (Mnler and Nau 2002). The values of the relationship

Part	Process characteristics	Process important	Reliability	Economy	Service life	Stability	Safety	Corrosion resistance	Wear resistance	Sealing	Compact	Maintainability	Final important (%)
Cylinder	The selection of material	101.37	○	◎	○	△	○	○	◎	◎			4.880
	Rough boring hole	33.79	△				△			△			1.627
	Precision boring	168.95	◎		○	○	◎			○		○	8.134
	Horning hole	168.95	◎	◎	◎	◎	◎			◎		◎	8.134
	Chromate treatment	168.95	○		◎	○			◎	◎			8.134
Piston rod	The selection of material	50.61	○	◎	○	△	○	○	◎	◎			2.437
	Cylindrical rough turning	16.87	△										0.812
	Cylindrical fine turning	84.35	◎		○	◎	◎			○		○	4.061
	Cutting slot	84.35	◎		◎	◎	◎			◎	◎		4.061
	Cylindrical Horning	84.35	◎	◎	◎	◎	◎			◎		◎	4.061
	Chromate treatment	84.35	○		◎	○	◎		◎	◎			4.061
Buffer valve	The selection of material	10.06	○	◎	○	△	○		○				0.484
	Cylindrical rough turning	30.18	△										1.453
	Cylindrical fine turning	50.3	△							◎			2.422
	Screw thread	30.18	○		○	○	○			◎			1.453
Guide sleeve	The selection of material	44.34	○	◎	○	○	○	○	◎	○			2.135
	Cylindrical rough turning	14.78	△							△			0.712
	Cylindrical fine turning	73.9	◎		○	◎	◎			○		○	3.558
	Cutting slot	73.9	◎		◎	◎	◎			◎	◎	◎	3.558
	Cylindrical Horning	73.9	○		◎	◎	◎			○		◎	3.558
	Rough boring hole	14.78	△							△			0.712
	Precision boring	73.9	◎		○	◎	◎			○		○	3.558
	Horning hole	73.9	◎	◎	◎	◎	◎			◎		◎	3.558
	Chromate treatment	73.9	○		◎	◎	◎	○	◎	◎			3.558
Sealing parts	The selection of material	122.55	◎	◎	◎	◎	◎	○	◎	◎			5.90
	Forming	122.55	◎		◎	◎	◎		◎	◎	◎		5.90
	Triming	73.53	△		△					△		◎	3.541
	Checking	73.53	◎		○	◎	◎			○		◎	3.541
Quality characteristic ratings			400.58	154.95	377.71	364.58	381.8	49.7	186.48	406.23	6.55	207.61	

◎=5 strong relationship △=1 medium relationship ○=3 weak relationship

Fig. 86.5 The quality characteristics HoQ for hydraulic cylinder matrix in the middle of the house are assigned 0,1,3,5 to represent an unrelated, weak, medium, and strong relationship between process planning and quality characteristics respectively as before. After forming the matrix, the process moves to deriving relative weights for the various quality characteristics. This was done by calculating the column sums and corresponding percentages of process characteristics. According to the quality characteristics ratings, we can identify the key quality characteristics that customers are interested. They are listed below from high to low in ratings.

Sealing, reliability, safety, service life, stability, maintainability, wear resistance, economy, corrosion resistance, and compact.

86.5.2 The Causal Analysis of Key Quality Characteristics for Hydraulic Cylinder

In order to meet the quality requirements of customer for hydraulic cylinder, the key quality characteristics associated with its manufacture should be controlled. The Cause and Effect/Fishbone Diagram is used to analyze the main causes that affect the key quality characteristics of hydraulic cylinder.

Cause and Effect/Fishbone Diagram, which proposed by Japanese Scholar Kaoru Ishikawa (Pavel and Jessica 2001; Zhang and He 2005), is effect tool for laying out the causes aroused quality problems and analyzing the relationship between causes and effects. By using this tool, the all factors affecting the quality characteristics for hydraulic cylinder can be drawn in a diagram, according to the 5M1E classification method. 5M1E indicates man, machine, material, measurement, method and environment.

The Cause and Effect/Fishbone Diagram for the sealing quality characteristic is shown in Fig. 86.6. Because of the limited space, the Cause and Effect/Fishbone Diagrams of other quality characteristic for hydraulic cylinder are omitted.

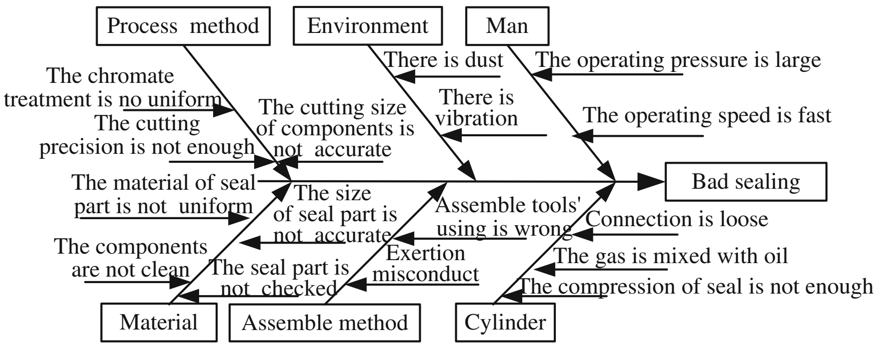


Fig. 86.6 The cause and effect/fishbone diagram of sealing quality characteristic for hydraulic cylinder

According to the Cause and Effect/Fishbone Diagram of the entire key quality characteristic for hydraulic cylinder, the causes aroused the quality problems are discovered. By concentrate on resolving and eliminating these causes, the hydraulic cylinder will uttermost meet the customer requirements.

86.6 Conclusions

Quality has become one of the critical competitive strategies in today's global market. Hydraulic cylinder, as a basics member for modern machinery and equipment, its quality is more and more paid wide attention by people. To ensure the improvement of quality and productivity of hydraulic cylinder, QFD has been used to translate customer needs and wants for hydraulic cylinder into technical design requirements by integrating the customer requirements, design specifications, part characteristics, manufacturing processes, and quality characteristics.

In this paper, Four HoQs for hydraulic cylinder such as product planning HoQ, component deployment HoQ, process planning HoQ and quality characteristic HoQ are built to help the decision makers to identify the key quality characteristic. By controlling these key quality characteristic, or examining the sensitivity of various quality characteristic deployment compositions with respect to changes in the weights of the customer requirements and their interests, as well as changes in strengths and weaknesses of the competition, the production quality requirements and customer requirements are ultimately met.

The Cause and Effect/Fishbone Diagram for the quality characteristics of hydraulic cylinder is drawn to help identify and analyze the causes aroused quality problems. By concentrate on resolving and eliminating these causes, the hydraulic cylinder will uttermost meet the customer requirement.

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Chapter 87
An Application Study of Lean Six Sigma in Logistic Service Quality Management

Hong-li Chen, Lu-lin Wang, Yu-feng Mu and Jing-xia Wang

Abstract In terms of technological process analysis, process waste and instability are major reasons for the high cost of logistics. Lean Six Sigma aims at the study of "value stream", which uses statistical tools to analyze the stability of technological process to reduce process waste and variation. Based on the application of Lean Six Sigma to logistic service quality management, the paper intends to look into the improvement for lean logistics through the analysis of distribution process of fresh food cold-chain logistics.

Keywords Lean six sigma · Service quality management · Technological process analysis

According to "2011 National Logistics Operation Report" jointly issued by State Statistics Bureau and China Federation of Logistics and Purchasing (CFLP), the ratio of China logistic total cost to gross domestic product (GDP) is 17.8 %, indicating that the logistic cost of social and economic running is still too high. Since 2005, the ratio of China logistic total cost to gross domestic product fluctuated around 18 %, since 2002, the correspondent ratio of the United States has been kept below 10 % (Zhang and Qiu 2010). The above statistics show that in transporting the same goods, the cost of Chinese logistic enterprise is the double of American logistic companies. Of course, there are various reasons for the high logistic costs in China. This paper attempts to argue that Lean Six Sigma management is the fundamental way to reduce logistic cost, because it can optimize logistic operation mode, reduce logistic process waste and enhance logistic service quality (Pu et al. 2011).

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87.1 The Present Quality Management of Logistic Enterprises

Our logistics is currently featured by high cost and low-level service. There are two aspects affecting logistic cost: one is the level of cost control by logistic enterprises, enterprise management level and logistic operation mode; the other is market system environment, including market operating mechanism and commodity circulation pattern, etc. (Weng 2011). As logistic enterprises operate under the existing market system, the market improvement needs the support of government and collaboration of all sectors. Consequently, Logistic companies improve their operation ability through constant adaptation to market environment. Therefore, what logistic enterprises can control and improve is their management level and operation mode so as to improve service and reduce cost. At present, Chinese logistic enterprises are featured by small scale, poor management and weak infrastructure. The majority of logistic enterprises can only provide some individual or sectional services including storage, transportation or distribution, while they are less capable of providing some value-added services like package and processing. Individual or sectional services lead to the increase in product turnover and the extension of transportation and inventory time, resulting in the possibility of cargo damage rate and error rate, correspondingly logistics cost increasing (Yu 2006). In addition, with the low level of information and the use of semi-artificial and semi-mechanical operation, the information flow is not smooth, and relevant departments can not ensure timely learning about the process of logistic service. Therefore, many problems frequently occur, such as high cost, successive years of low profits, lost product, distribution behind time, substandard quality and so on. In order to Improve service and reduce cost, waste and variation in logistic process to ensure the goods' timely, accurate, and safe delivery to customers.

The enterprises always strive to strike a balance between service quality and cost to meet the requirements of customers and lower costs. For example, SONY improved the product packaging based on the principle of "Reduce, Reuse, Recycle, Replace". Under the precondition of guaranteeing the packaging quality, the cushion packaging of large TV sets is made by eight small pieces of division packaging (EPS), instead of previous whole piece of foam plastic materials (EPS), thus reducing the use of 40 % EPS. Among them, some products are packaged by EPS material in front and corrugated cardboard in back, and the special form of corrugated cardboard boxes are used for outer packing to save resources. Lean Six Sigma management aims to reducing waste and variation in the process of service, and improve service without any increase in cost.

87.2 Define Waste and Variation in Logistic Process

Lean Six Sigma is produced by effective integration of lean manufacturing and six sigma. Lean Six Sigma makes up for the deficiencies of both lean manufacturing and six sigma, and establishes a three-dimensional system, taking into account the factors of cost, quality and speed (Feng and Xing 2008).

87.2.1 Apply Lean Production to Define Logistic Value-Added Activities

From customer's perspective, with the object of value stream, lean manufacturing aims to provide customers with satisfactory products and services with high efficiency through eliminating excess waste and loss as much as possible. Lean manufacturing focuses on "value stream" and it quickly and effectively solves the waste problem without large amounts of data, relying on logical thinking and experiences (Ou et al. 2011). For logistic service process, enterprise process activities are analysed through value stream diagram. Business process activities fall into three categories. The first type is value-add activities, including packing and distribution processing, which increase the value of product sales. The second one is no value-added but necessary activities, such as loading and unloading, transportation, storage, etc. The third is no value-added and unnecessary activities, known as waste, such as excessive processing. Enterprises should retain the first and second categories, and apply lean production tools to eliminate waste.

87.2.2 Apply Six Sigma to Define the Variation of the Logistic Process

Sigma is a statistic term, representing standard deviation, and a sign of measuring quality level. If the quality level achieves six sigma, it explains defect rate of 3–4 of million opportunities. Now most enterprises can achieve the level of 3σ–4σ. Six Sigma is based on data and facts, using various statistic tools to analyze the influence factors of quality variation in the process, and identify the key factors to improve (Zhao and Zhang 2006).

Logistic service quality focuses on time, accuracy, product quality and other indicators, which directly reflect logistic process capability. Logistic service involves the time indicators as follows: the time of order processing, storage, picking, loading, unloading and transportation (Song 2007). The project team collects the time of different logistic operation process for accomplishing the same logistic functions. With the use of the statistic software, they analyze the above-mentioned time horizontally and vertically and observe the data to see whether there is an abnormal situation. The last step is the project team uses fishbone diagram or other methods to analyze the cause of abnormal situation. The accuracy of logistic service contains commodity delivery time/place accuracy and the exact number and the kinds of commodity. Six Sigma has a set of complete mode to measure and analyse process.

87.2.3 Lean Six Sigma Management Methods

Two is that Lean Six Sigma designs the whole process, and it integrates lean production. Basic mode of DMAICII is as follows (Wang and Zhao 2005):

(1) Definition stage. Define customer demand and analyse system; identify relevant performance measurement, benchmark best performance standard; confirm six sigma project.

(2) Measurement stage. Measure the time of process operation, verify the effectiveness of the measurement system, and use Minitab software to evaluate process capability.

(3) Analysis stage. According to process capability index, analyze process, find source of waste or variation, and determine the key process factor of input or output.

(4) Improvement stage. Propose optimization solution and improvement plan, eliminate factors leading to waste or variation, optimize input and output in distribution process.

(5) Control stage. Maintain the stability of input and output, establish standard operation for service process, and implement process control, test measurement system, process and ability, summarize results, regulate successful experiences, and put forward new problems.

87.3 Analysis of Fresh Food Cold Chain Distribution Process

Fresh food refers to the fresh vegetables, fruits, meat, poultry, livestock and aquatic products, etc., which are grown, picked, raised, fished, without hot processing such as cooking. Fresh food in the storage and distribution process requires high standard of temperature, environment and health. If any of the factors does not meet the standard, the food will go bad. Therefore, in the process of the distribution of fresh food, it is necessary to strictly control the range of fluctuation of temperature, humidity, environment and health. However, due to the low level of development of Chinese cold chain logistics, there are many instable factors throughout the distribution process of fresh food, such as serious traffic congestion, which may prolong transportation time, and no refrigeration equipment in the truck, resulting in goods deterioration (Miao et al. 2009).

With cold chain logistic distribution of fresh meat as an example, the basic mode of Lean Six Sigma DMAICII is used, and a set of optimized programs are designed based on quality, cost and efficiency. We identify the waste in distribution process, and determine the instable factors and variation in the process and use specific tools to reduce waste and variation.

(1) Definition stage

Establish a project team, determine its name as optimization of fresh food cold-chain in logistic distribution process, and use value stream diagram to ensure distribution process, as shown in Fig. 87.1.

According to Fig. 87.1, each process is no value-added and necessary activities, and the factors contributing to these activities are shown. The second column shows the enterprise's existing mode of operation, the third column shows the measured results of output after each operation, and these data reflect enterprise's existing process capability (Table 87.1).

(2) Measurement stage

The content of the measurement is divided into two kinds, and the first kind is the measurement process indicators such as time, temperature, health conditions, among which temperature measurement during transportation should be made in some chosen observation spots. The selection of observation spots are related to transportation time and distance, and the specific way is decided by enterprise, using Minitab software to measure the fluctuation of indicators. Because different measuring systems produce different data, the validity of measurement system should be verified after data measuring, measurement system including time measuring equipment, temperature measuring equipment, and final evaluation process ability; The second type is measuring the rationality of working process, results are analysed according to process capability. The management looks for irrationality of process operation mode and producing area layout based their logical thinking, experiences and related tools. Meanwhile, they should pay attention to and listen carefully to the suggestions from operation personnel, because their views are highly significant.

(3) Analysis stage

Based on the above two data, we should find the cause contributing to quality problems in fresh meat distribution, including improper temperature control, sub-standard health condition or operation time. Improper operation methods not only affect the process efficiency but also lead to abnormal situation. On the basis of national standard we should measure if enterprise operation mode meets the standard. First, detect temperature control in warehouse, loading areas and transportation. Second, check storage environment, loading/unloading, transportation equipment and personnel health condition. Last, examine reasons contributing to improper operation, working staff's loose discipline, improper working areas or other reasons. Use fishbone diagram to identify key factors.

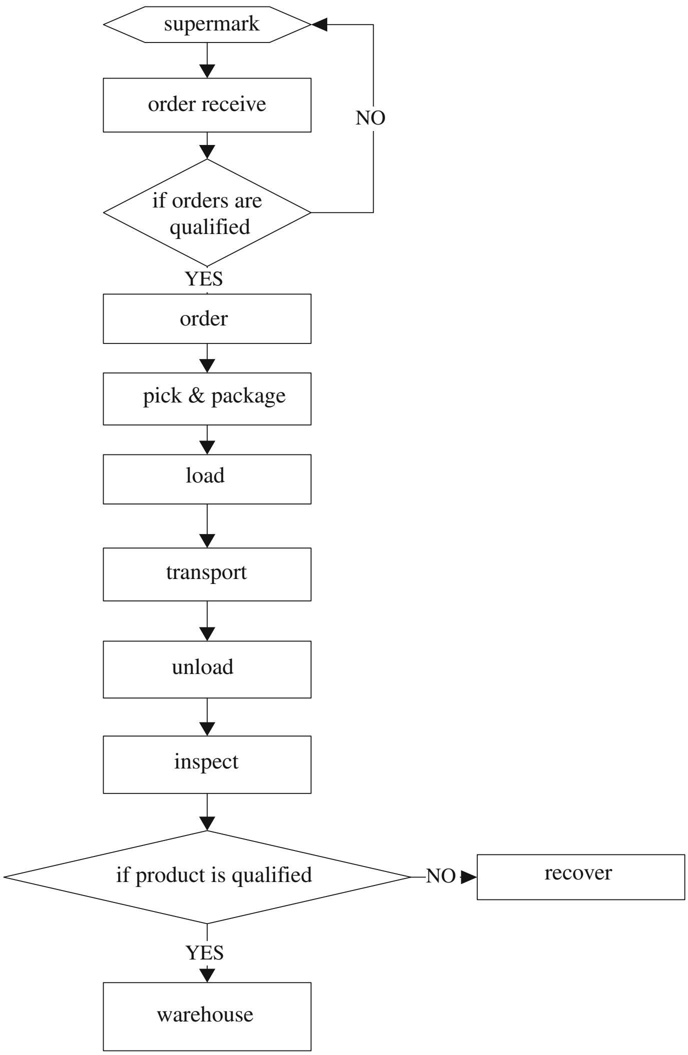

Fig. 87.1 Fresh meat distribution stream

(4) Improvement stage

Before designing program, aimed at key factors, the project team discusses the following problems for improvement. (1) Whether it is used for other purposes? (2) Adaptation, correction, expanding, decrease, replacement. (3) Rearrangement. (4) Reverse. (5) Combination. Through a series of ideas, evaluate and select the most likely improvement plan. In order to carry out the plan effectively, project team is responsible for improving the implementation of the plan, arranging what to do, where to do, when to do and how to do it.

Table 87.1 Input and output in distribution process

Process	Factors affecting operation	Results of output operation
(1) Order receiving, processing	(1) Order operation modes: (a) Artificial relay (b) Network informatization (c) Human–machine combination	(1) Order processing time (2) Out of stock rate
(2) Picking and packaging	(2) Picking way: (d) Manual handling (e) Mechanical work (3) Picking equipment, personnel hygiene (4) Picking procedures: (f) Picking according to order (g) Picking according to distribution number	(3) Picking time (4) Distribution accuracy
(3) Loading	(5) Loading equipment, personnel hygiene (6) Temperature, humidity in loading section (7) Environment in loading section	(5) Loading time (6) Commodity quality
(4) Transportation	(8) Types of transportation vehicle (9) Refrigeration equipment, temperature and humidity control equipment (10) Traffic	(7) Transportation time (8) Damage rate (9) Timely delivery rate

(5) Control stage

The control stage focuses on maintaining improvement. Regulate temperature control, realization mode, standard hygiene condition of equipment and personnel, standard operation in different stages, and set the biggest floating range of variables. Because Lean Six Sigma needs certain statistic knowledge, and in control stage process capability and efficiency should be regularly tested, it is necessary to strengthen staff training. In order to help the Lean Six Sigma's team understand clearly the tools in different stages, we give Table 87.2 (Wang 2009).

Table 87.2 Selection of the tools of Lean Six Sigma

Definition	Measure	Analysis	Improve	Control
Target State Pareto chart Flowchart analysis SIPOC Kano analysis Benchmarking Suggestion system	Relation matrix Process capability analysis Check list Causal analysis System analysis Scatter diagram Histogram TPM	Regression analysis Variance analysis Causal analysis Correlation analysis Multi-variation analysis Fishbone diagram Hypothesis testing	Brain storm Experiments design Ballot analysis Affinity diagram Cancel cooperate rearrange simply KANBAN SMED	5S management Control chart Continuous improvement Full control Process activity diagrams

87.4 Conclusion

To solve the logistic distribution service quality, Lean Six Sigma management has a strong suitability; especially statistical tools can clearly provide the cause of problem and improved standards. However, because of the particularity of logistic service industry, many indicators cannot be accurately acquired, thus limit the application of Lean Six Sigma in the field. With the intensified efforts of the operation standard in logistic enterprise, lean logistic improvement method will be more convenient and useful.

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Chapter 88
A COPQ-Based VOC and Core-Process Analysis

Chee-Cheng Chen and Shuo Zhao

Abstract This research applies the Ford eight-disciplines (8D) problem solving method to analyze customer complaint events as voice of customer (VOC), combining cost of poor quality (COPQ) analysis to measure the cost/loss business cause through transforming the event severity into a common measurement language—money accumulated to the root cause source (a department or process) to define the core process in a specific period. An enterprise shall do everything to meet customer requirements with limited resources. To identify the core process and concentrate on it to yield satisfactory results with less effort is the goal. This study develops a mechanism for defining core processes using voice of customer and cost of poor quality analyses for enterprises' reference in practice.

Keywords COPQ · Core process of enterprise · Ford 8D · Voice of customer

88.1 Introduction

With the progress of modern society, especially the rise of the current global technological revolution, an environment full of competition and challenges, improving production and business activities in a competitive market, new ways to solve problem must continually be developed. As competition becomes stiffer, more companies and organizations are trying to reduce their non-value creating costs as a means of increasing their competitiveness. The quality of products or services is the core product the customer desires, an important factor in customer satisfaction. The cost of poor quality (COPQ) is an important tool to measure invalid and non-value added management practices activities.

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Many enterprises are facing the high cost of poor quality and customer complaints, an important performance indicator of VOC (Voice of customer). It is difficult to find the real reason for this problem through the traditional improvement method. However, 8D is an effective way to discover the real reason that is applied to analyze events of voice of customer, combining COPQ analysis to measure the cost/loss accumulated to the root cause source (a department or process) to define the core process in a specific period. A case study is used to prove the model's applicability and suitability.

88.2 Literature Review

88.2.1 8D

The 8D-method has its historical roots in the quality standard MIL-STD 1520 "Corrective Action and Disposition System for Nonconforming Material", issued by the US military. Introduced in 1974, it describes a cost efficient plan of action to handle and dispose of non-conforming material. The processes and handling of information between involved parties are described. The main goal is the identification of errors, the root cause analysis, the limitation of waste, the prevention of fault reoccurrence, cost reduction in production and a general increase in quality. This guideline was used by all US military suppliers until 1995 (Berk and Berk 2000).

The Ford Motor Company developed team oriented problem solving (TOPS) based on the 8D-method (Tops 1992). Because this method was divided into eight disciplines, it was also named 8D-method (Krause et al. 1996). Later the VDA published its own version for OEMs and suppliers of the automotive industry in Germany. It is now in common use for processing customer complaints (Edler 2001).

The best known method to handle complaints is the 8D-Report which is the standard method within the German automotive sector (Verband der 2010). Over time it has become accepted more and more by international companies as well. The 8D-Report contains eight steps to be executed consecutively (Effey and Schmitt 2011).

The automotive industry in Germany has agreed on a common method to deal with complaints and to communicate these to the suppliers. This method is called 8D-Report (D for disciplines), installed by the German Association of the Automotive Industry (VDA) (Krause et al. 1996; 8D-report definitions 2003). It is a standardized procedure to handle fault complaints and their corrective action plans (Edler 2001). Within this method, the filed complaint is sent to the supplier, who sets up a team to deal with the complaint (Behrens et al. 2007).

88.2.2 Voice of Customer

Listening to the voice of the customer (VOC) is the starting point for planning and/or adapting services to satisfy customer needs and requirements. This means that improving the quality of any service, including health care, is likely to be unattainable unless the voice of the customer (or service user or patient) which is brought into the service improvement process (Aghlmand et al. 2010).

VOC refers to articulated and unarticulated customer needs and requirements. As such it must be identified in order to start new process development (Duhovnik et al. 2006).

VOC analysis is a distinct feature of QFD, although its special tools and techniques can also be used alongside other process improvement methods (Carey and Lloyd 2001).

VOC analysis can play an important role in understanding customer requirements in a new product or service. Moreover, it can provide value to customers and can leave the customer with a favorable impression (Sung et al. 2005).

88.2.3 Cost of Poor Quality

Poor-quality cost is defined as all of the cost incurred to help the employee do the job right every time (this includes process designs that have non-value-added activities included in them) and the cost of determining if the output is acceptable, plus any cost incurred by the organization and the customer because the output did not meet specifications and/or customer expectations (Harrington 1999).

Taguchi defines quality as, "The quality of a product is the (minimum) loss imparted by the product to the society from the time product is shipped". The classic case to introduce the Taguchi's poor quality cost is the case of Ford versus Mazda (Tsou 2007).

Reducing a company's non-value creating costs—the cost of poor quality—is one of the best ways of increasing profitability and competitiveness, yet ineffective measurement prevents many businesses from realizing the benefits (Sörqvist 1997).

88.3 Method

88.3.1 Popular Model Review

Currently, Ford-8D methodology, 8-steps as Table 88.1 without column at right side of dot-line showed, is applied to analyze root cause and take corrective and preventive actions for customer complaints, defined as an important performance

Table 88.1 8D combined with COPQ analysis to measure the cost of each step

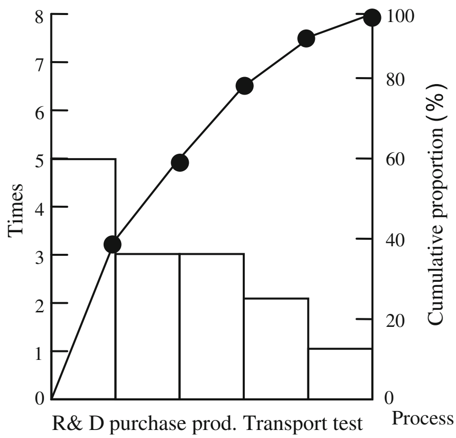
Discipline no.	Action description	Completion date/by	Cost impact
Discipline 1	Use team approach, verify customer complaint	Date of occurrence/	The cost of discipline 1 (Cd1)
Discipline 2	Describe the problem	Completion date/	The cost of discipline 2 (Cd2)
Discipline 3	Implement and verify interim containment action	Completion date/	The cost of discipline 3 (Cd3)
Discipline 4	Define and verify root cause	Completion date/	The cost of discipline 4 (Cd4)
Discipline 5	Choose and verify permanent correct action	Completion date/	The cost of discipline 5 (Cd5)
Discipline 6	Implement permanent corrective action	Completion date/	The cost of discipline 6 (Cd6)
Discipline 7	Prevent recurrence	Completion date/	The cost of discipline 7 (Cd7)
Discipline 8	Congratulation your team	Completion date/	The cost of discipline 8 (Cd8)

indicator of VOC (Voice of customer). The customer complaint attributes can be sorted for a certain period, for instance, trend of number, root cause and process owner or department of problem source in order to take right actions for improvement. A Pareto diagram is organized based on the accumulated customer complaint numbers versus process or department (process owner) respectively on quarterly or yearly basis that is used to define the company's core processes by enterprises popularly. An example of A Company, total 14 customer complaints that was analyzed to form a Pareto diagram with number-based indicator of VOC versus department at the end of year, 2011 as Fig. 88.1 showed. The R&D process was defined as the core process that should take action with top priority.

In practice, the VOC performance measurement systems were unable to quantify the cost impact of customer complaints and the achievement levels of improvement actions in the past decade. The number-based measurement system cannot highlight the cost-effect or business concerns in a Just-In-Time manner that will promote improvement effectiveness. The advantages of establishing a new model is obvious after analyzing the concerns listed below.

(a) Impact of cost: The model does not help highlight the severity of customer complaints and their possible impact on the organization.
(b) Effectiveness of actions: The percentage of defects inside lots from various stages of handling in field of customers are sometimes extremely different and may significantly impact profits that may be caused by poor corrective and preventive actions, should also be brought to management's attention.

Fig. 88.1 Pareto diagram of number-based VOC analysis



88.3.2 The Establishment of COPQ-Based Model

A COPQ-based measurement system developed in conjunction with the A Company was developed. The system integrates three main areas of the company: management, quality improvement team and customer. To achieve an integrated system, the three areas are linked through the specification, reporting and updating of the defined formula of measures and standards. The Table 88.2 with dot-line column is used to present the cost calculation. Three main portions of costs are measured in this study: C_{CC} (Cost of customer complaint), Cdn (Cost of nth-step handling discipline) and Cmi (Cost of management involvement). The estimated cost of voice of customer (C_{VOC}) will be defined using Cd1, Cd2……Cd8, as showed in Table 88.1 as below,

(a) Cost of Customer Complaint,

$$C_{CC} = (1 + r) \times Cd1. \tag{88.1}$$

A company applies the multiplier (r) method that assumes that the total consequential costs of failure are simply some multiple of the measured costs:

Total consequential costs of failure = $r \times$ (Measured external failure costs).

Where r is the multiplier effect, the value for r is based on experience. Assessing the amount of consequential costs for failure allows management to

Table 88.2 The multiplier of a company

The severity of the event	Multiplier
a. Only complaint without return	r = 2
b. Complaint and products to be returned	r = 5
c. Complaint and to recall products in the market	r = 10
d. Complaint and compensation required	r = 20

determine more accurately the level of resource spending for prevention and appraisal activities.

Specifically, with an increase in failure costs, we would expect management to increase its investment in control costs. The multiplier r of A company has been defined & classified 4 levels, as Table 88.2 showed.

(b) The cost of handling disciplines, Cdn, Cost from D2 to

$$D8 = Cd2 + Cd3 + Cd4 + Cd5 + Cd6 + Cd7 + Cd8 \tag{88.2}$$

All of the quality costs are observable and should be available from the accounting measurements using well defined handling procedures (SOP) or instructions. Once activities are identified and described, the next task is determining how much it costs to perform each activity. This requires identification of the resources being consumed by each activity. Activities, which consume resources, are items such as labor, material, energy and capital. The costs associated with each customer-complaint "event" can be the actual cost per event or an average cost per event. This data may be collected through interviews with selected/related managers and non-management personnel to establish average resources, times and the cost associated with various events.

(c) Cost of management involvement,

$$Cmi = p \times (Cd2 + Cd3 + Cd4 + Cd5 + Cd6 + Cd7 + Cd8) \tag{88.3}$$

The cost of management involvement associated with each customer-complaint "event" can be assumed a proportion (p) to the cost of handling disciplines, formula (88.2), to effectively lead engineering efforts. This data may be collected through interviews with selected/related managers to determine the p value which may be different from firm to firm. The p is set as 10 % by a company.

(d) Cost of VOC,

$$\begin{aligned} C_{VOC} &= V \\ &= (1 + r) \times Cd1 \\ &\quad + (1 + p)(Cd2 + Cd3 + Cd4 + Cd5 + Cd6 + Cd7 + Cd8). \end{aligned} \tag{88.4}$$

88.4 Results Comparison

The same example is presented to demonstrate how the proposed COPQ-based model, Formula (88.4). The Pareto diagram with Cost of VOC (C_{VOC}) versus department as Fig. 88.2 showed could be applied to VOC performance measurement and to compare it with the popular number-based model as Fig. 88.1 showed. Significantly sensitive, accurate and effective VOC performance rating results

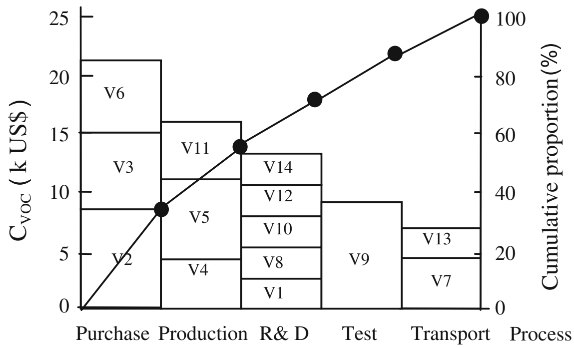


Fig. 88.2 Pareto diagram of COPQ-based VOC analysis

through applying the new model, formula (88.4), have been obtained compared to the popular model. The purchasing process is defined as a core process instead of the R&D process based on COPQ-based model analysis.

88.5 Conclusion

The 8D problem-solving method, combined with cost of poor quality analysis and the voice of the customer were used to define a company's core process in this paper. Analysis of a specific case using the COPQ-based model of VOC analysis established in this study can effectively define the core processes. The core process defining system using cost of poor quality as proposed in this study can be very beneficial for management in selecting the most critical process and driving operating quality improvements. The merits of measuring VOC performance using COPQ analysis include: (1) a common language of measurement—money, (2) very simple and visible numbers along with ratios of the direct and indirect loss to help management and employees understand the importance of "doing things right the first time".

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Chapter 89
Quality Evaluation of Waste Electromechanical Remanufactured Product Based on the User's Satisfaction

Wen-yong Zhou, De-yong Zhang and Ying Xu

Abstract Waste machinery remanufacturing is a producing behavior in recycling economy, as well as a manufacturing behavior facing to users. The aim of remanufacture is not only making full use of resources, but also satisfying user's need. Since products are the material links between enterprises and customers, and the quality of which is the basic of achieving customers' satisfaction, it is particularly important to establish a quality evaluation system of remanufacturing product based on user's satisfaction. From the user's perspective, the objective and principle of remanufactured product quality evaluation are clarified, and the model of which is built after designing an index system from four aspects based on user's satisfaction, in order to provide new ideals and methods for waste electromechanical remanufactured product (WERP) quality management.

Keywords Quality evaluation · Remanufacturing · User's satisfaction · WERP

89.1 Introduction

Remanufacturing of waste electromechanical product becomes a very important part for accelerating the development of circular economy and building a conservation-minded society to China, since the conception of waste resources and efficient use was put forward. Waste electromechanical remanufacturing is widely

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concerned by academic community and enterprise since it was first proposed in 1994. Researches have been made from many respects such as the remanufacturability (Lund 1984), reverse logics of waste electromechanical (Jayaraman et al. 2003) and so on. What's more, the businesses of waste electromechanical remanufacturing are gradually carried out, and have made a great progress. According to statistics, the scale of global remanufacturing industry is more than $100 billion at present, and remanufacturing industry of the United States is the earliest, biggest and best development. While the concept of remanufacturing engineering was not introduced into China until 21st century, the industry has only 10 years' history with much smaller scales, which needs further development.

At present, the research on waste electromechanical remanufactured product (WERP) quality evaluation is still limited. Kimura (1998) proposed a method of quality evaluation for waste electromechanical products by computer simulation, and then took duplicating machine as an example. Then, Westkamper and Alting (2000) setting up an index system with the method of life cycle management and LCM/A method including five indexes such as the user's demand, product quality, cost savings, reducing the environmental burden and global interests. On the basis of the analysis of the sources and characteristics of the quality volatility, Yao et al. (2006) put forward the remanufacturing process quality control methods based on the total quality management, statistical process control of the remanufacturing process and the quality control technology of the remanufactured product. Li et al. (2009) combined the evaluation index of the remanufactured product quality and the degree of customers' satisfaction on the basis of the QFD method, then built the product remanufacturing quality evaluation house, calculated the importance of WERP evaluation index. These studies realized the importance of WERP evaluation, and put forward some indexes and methods to evaluate the quality. But there is still lack of a systematic and comprehensive index system, and technical methods of remanufactured product evaluation is needed.

Since quality of remanufactured product is the key factor of successful remanufacturing, product quality evaluation is of great importance to insure the quality of WERP. In this paper, combining the features of general product quality evaluation and WERP, a remanufactured product quality evaluation index system is put forward based on the user's satisfaction, and then a remanufactured product quality evaluation model is established, which is conducive to resolve a series of problems in quality evaluation of WERP. We hope to provide the waste electromechanical remanufacturing enterprise a new approach to evaluate WERP, and change the bias of remanufactured products' quality assurance, thus promoting the development of the remanufacturing industry in China.

89.2 Objective and the System of Remanufacured Product Quality Evaluation

It is required that the quality and performance of WERP should be greater or equal to the original ones, in order to achieve the multiple life cycles and products' sustainable development, in addition with life cycle cost reducing, resource saving, and pollution decreasing. Meanwhile, remanufacturing industry also creates a large number of employment opportunities, which will become a new and rapid growth point of social economy (Yao et al. 2009). Therefore, the purpose of WERP quality evaluation is to ensure the WERP performance and quality, which needs to find the key process influencing WERP quality by tracking all aspects of the process, thus making improvements of overall efficiency and high quality, finally achieving user's satisfaction.

Based on user's needs and the characteristics of electromechanical products, an index system which contains product life, technical performance, reliability, user-friendly and economic performance is built (Zhang 1988; Wang and Li 2009; Li 2010; Liu and Cao 2007; Coulibaly et al. 2008), showing in Table 89.1.

Mainly related to the life of the WERP are economic life and physical life. For users, the physical life of the product must meet or exceed the economic life; the value of the product must exceed the total cost of the product in life cycle. To meet the needs of users, the remanufactured products must achieve the physical wear and obsolescence synchronization. Due to remanufactured products is affected by recycled parts, yet the enhancement of the technical performance can slow the loss, so remanufacturing project is best to extend the overall life cycle of WERP.

The technical performance of the product describes the basic functions of the product and its technical indicators, including running speed and processing efficiency, present product technical performance indicators can be used as the basis of the evaluation. Speed is the assurance of processing efficiency, and processing efficiency is a concentrated expression of the product technical performance.

Table 89.1 WERP quality evaluation index system based on the user's satisfaction

First class index	Second class index	Index explanation
Product life	Economic life	Life of remanufactured product
	Physical life	
Technical performance	Running Speed	Whether performance indicators improve or not
	Processing efficiency	
Reliability	Security	Whether the product safe and reliable or not
	Persistence	
User-friendly	Handle convenient	Whether user interface convenient or not
	Humanness	
Economic performance	Purchase expense	The economic performance and the sum of product life

Remanufactured products need to improve speed, enhance processing efficiency on the basis of the original product to better serve users. All of this needs to make the creation and progress of the process (Zang and Liu 2007).

The reliability of WERP mainly inspects on the sustainability and security of remanufactured products. Sustainability refers to the product trouble-free operation for a long time, the average failure probability is low, fault repair is relatively easy and fast. The safety of products means that remanufacturing has effective security measures and equipment, low probability of accident, the lowest accident danger and damage even improper operation happened to protect the user's security.

User-friendly shows in the convenient operation of WERP and the humanness degree of the user's interface. Remanufactured products need to be easy to operate, major operating facilities and equipments should be placed in the easy getting location, the equipment generally balanced, and must easy to use. The Humanness of the user interface is reflected in corresponding with the public body, habits, behavior and operating characteristics, Then try to meet the special needs of specific areas, and develop a variety of modes for users to choose to ensure customers' satisfaction as far as possible.

Economic performance is that the acquisition cost of WERP and cycle usage fees must be reasonable. Acquisition cost is a one-time cost, but the cost of the period of use is a long-term and continuous expenditure. Many producers have ignored these important costs, resulting in large losses. In order to ensure reasonable indicators of cost-effectiveness of remanufactured products and reduce customers' total spending for customer satisfaction, economic performance requires total cycle of the product at a reasonable cost and usage charges to a minimum (Jiang et al. 2011).

89.3 The Remanufacured Product Quality Evaluation Model Based on the User's Satisfaction

From user's perspective, this article constructs WERP quality index system which contains product life, technical performance, reliability, user-friendly and economic performance based on the evaluation target of remanufactured products. That requires the application of some methods such as literature review, brainstorming, performance evaluation, telephone interviews and depth of research method for the derivation and calculation of the evaluation model. As a conclusion, WERP quality evaluation model is shown in Fig. 89.1.

As Fig. 89.1 shows, the implementation of quality evaluation begins with determining the objectives and impact factors of quality evaluation. The purpose of that is to improve the WERP quality and achieve user's satisfaction by assessing. Since the subject is WERP, the evaluation factors include raw materials, remanufacturing process and evaluation model: Raw materials are the rough and parts of waste electromechanical, and the performance of that is directly relevant

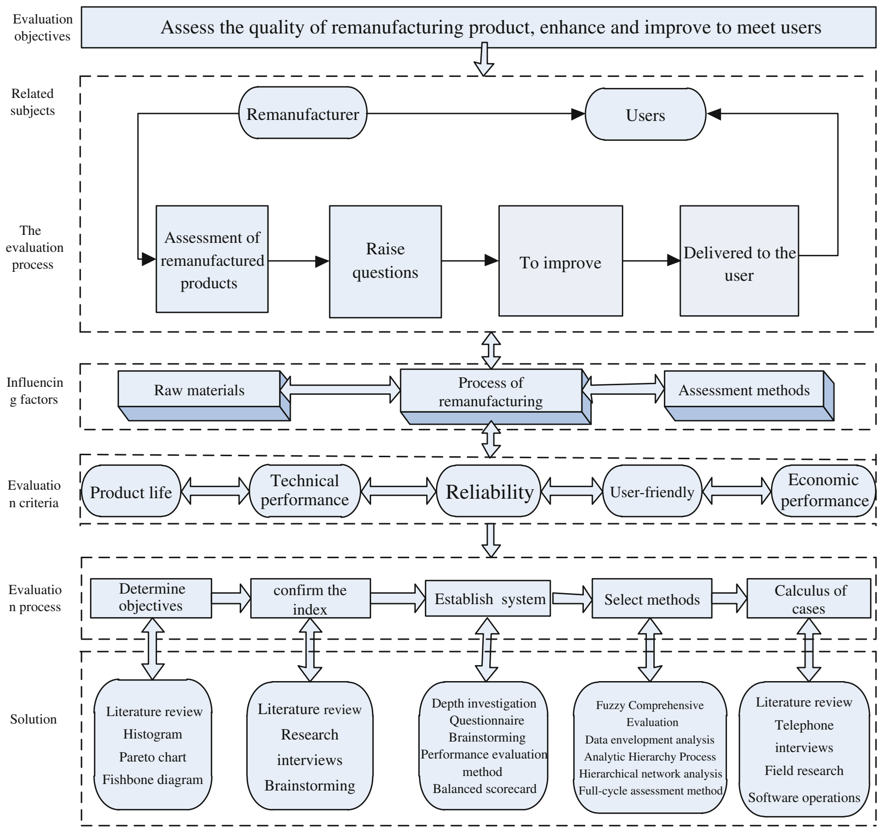

Fig. 89.1 WERP quality evaluation model based on the user's satisfaction

to the final quality of remanufactured product; Remanufacturing process consists of testing, cleaning, disassembling, repairing and re-assembling, and any improper operation of these processes will lead to quality problem; Finally different assessment methods will produce different results. After the evaluation of remanufacturing product based on user-centered thinking, re-manufacturers should find the problems of raw materials or remanufacturing process, and make improvements and adjustments by analyzing the root causes of these problems until the product meets all the requirements and being delivered to the user. During the process, evaluation and improvement may cycle many times, in order to find a series of problems in the system and modify.

As for the index weight in particular, the scores of each indicator are given using the quantitative and qualitative methods under the guidance of the five indicators. After determining the index weight with a qualitative and quantitative method (Zeng and Wang 2007), the performance of each index should be scored by experts and users, thus calculating the score of remanufacturing product and each indicator. Then analyses the final results, to identify the problems and find where can be improved.

89.4 Conclusion

In this paper, a quality evaluation index system and an evaluation model of WERP is established from a new point of view. When putting forward the index system aspects such as product life, technical performance, reliability, user-friendly and economic performance have been concerned. Then a quality evaluation model of remanufactured product is constructed based on user's satisfaction, and the evaluation process of that is described and explained. Finally propose some solutions for some practical problems.

Nevertheless, there are still some inadequacies in this study. First, the specific quantitative of evaluation index system requires a certain mathematical means, such as the analytic hierarchy process to determine the index weight, in which actual cases is needed to support and inspected. In addition, differences of evaluation index system from various enterprises being selected cannot be neglected. Therefore, combining the specific requirements of different enterprises, and establishing a rational evaluation index system still needs further discussion.

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Chapter 90
A Study on Synergic Quality Management in Bags Enterprise Supply Chain

Ming-li Zhang and Li-xia Lei

Abstract It is estimated that china's bags production accounted for 50 % of world production. Although the numbers of bags production is very large, but mainly occupy the low-end market, take little occupation of the high-end market, the main reason for this phenomenon is bags quality problems. Due to the particularity of the luggage industry, it requires more coordination and cooperation between the enterprises of the supply chain. This paper takes research of bags supply chain quality control mechanisms by supply chain collaboration principles method. In addition, the paper also analyzes common quality problems in bags production, put forward bags supply chain collaborative quality control mechanism and operation method.

Keywords Supply chain · Collaborative quality management · Bags enterprise · Quality defects · Control mechanisms

90.1 Introduction

In the supply chain environment, many companies and their partners (including suppliers, distributors, logistics providers, ISP, etc.) became more closely linked, which makes people realize that competitive advantage is not just a simple product quality and process quality, but the overall quality control of the whole supply chain system (Huang and Sunil 2005). As a result, focus of quality management research transferred from a single enterprise to the supply chain. At present, China bags have been exported to more than 200 countries and regions. It is estimated that the total output of bags about 50 % of world production. Although the

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numbers of bags production is very large, but mainly occupy the low-end market, take little occupation of the high-end market, the main reason for this phenomenon is bags quality problems. We have no specific quality standards for bags in our country. This paper aims to complete bags enterprise supply chain collaborative quality management, and then completed the quality control of goods production, just by building a supply chain collaborative model of quality management.

90.2 Methodology

90.2.1 Concept of Supply Chain Collaboration

The concept of supply chain collaboration (SCC) proposed by the consulting industry and academia in the mid-1990s. But the idea of SCC has been generated in 1989. In 1989, Stevens proposed a four-stage model of integrated supply chain, which including: Infrastructure construction, Integration of functions; integration within the company; integration outside the company. Overall, supply chain collaboration means that "To achieve the overall objective of the supply chain, supply chain companies jointly developed the plan, implementation strategy and operating rules, and mutually agreed to bear the relevant responsibilities so that the enterprises of the supply chain can move forward together". It is worth noting that the supply chain collaboration is not just a set of technologies (such as CPFR), it also contains much more complex ideas and skills (Robinson and Malhotra 2005). Supply chain collaboration beyond the extent between enterprise and suppliers or their customers, it also includes the collaborative planning, forecasting, distribution, product design and other areas of tactical joint decision-making.

90.2.2 Requirements of Synergic Quality Management in Supply Chain

In accordance with the elements of supply chain collaboration, synergic quality management in supply chain including the collaboration of quality concept, collaboration of quality assurance ability, collaboration of quality information, collaboration of quality organization, collaboration of quality standards.

(1) Quality concept collaboration. Quality concept is the views and opinions formed in the companies' quality management activities (Tan 2001). Collaborative quality management concept is the basis of the decision of supply chain quality management.
(2) Quality assurance ability collaboration. Supply chain quality assurance capabilities including the ability to develop and design new products, ability of quality control, ability of quality improvement, ability to respond to market

demand and customer expectations, organizational learning capability (Posenblatt and Lee 1986).

(3) Quality information collaboration. Collaboration of quality information refers to that making the scattered quality information and quality knowledge integrated to eliminate the "islands of information" of supply chain (Pagel 1999).

(4) Quality organization collaboration. Organization of supply chain collaborative quality management must focus on core business, to support the core businesses and suppliers, vendors' dynamic alliance, and to create value for end users

(5) Quality standards collaboration. Collaboration of quality standards includes: (1) Technical standards collaboration; (2) Management standards collaboration; (3) Performance standards collaboration (Bowon 2000).

90.3 Results

90.3.1 Analysis of Quality Defects in Bags Enterprise Supply Chain

In accordance with the luggage industry terminology, as well as the industry's long-term conventional concept of the quality defects, defects of bags products can be summarized from the product design, materials accessories, technical operation, sewing, assembly ways. Quality Defects in bags enterprise supply chain include the following aspects:

(1) Bags quality defects caused by material defects. (1) Fabric defects. Fabric defects including scratch fabric, the fabric material information is not true, the fabric lining of non-compliance. (2) Hardware material defects. Hardware material defects includes Hardware injured, hardware uneven color, hardware scratches, hardware burnt metal pinholes, hardware plating, the appearance of a pinhole-like pits, metal parts from leather, foam coating, leakage plating, oxidation spots. (3) Other accessories quality defects, such as lines, machines and other issues

(2) Bags quality defects caused by unreasonable operation. (1) Defects on the appearance and operation: Poor shape, the structure is irrational, package is not correct, the length dimensions out of tolerance, the product weight exceeds the standard specified target, box suture gap deformation box, ox collapse, uneven surface. (2) Defects on the metal parts and assembly: Asymmetric accessories, accessories loose, box lock failure, bubble nails falling from the bags wheels falling down from the bags, wheels damaged, the zipper is missing the chain teeth, the zipper pull together the non-smooth standard; Non-standard operations: Jumper off the assembly line, not straight stitch,

stitch length is too large, exposed thread, left edging blank, dental sub-line exposure, poor corrosion resistance, zipper flat tensile strength.

90.3.2 Synergic Quality Management Model in Bags Enterprise Supply Chain

According to the problems of bags enterprise supply chain quality control, Synergic quality management model in bags enterprise supply chain should include the following characteristics:

(1) Use agent technology to improve the system's intelligence, applicability. This system is a collection of multi-agent, including the plan agent, coordinating agent, sales agent, purchasing agent, producing agent, inventory agent, financial agent (Cheng 1991).
(2) Providing the optimization and decision support, and building partnerships with upstream and downstream enterprises to achieve information sharing and business integration, to achieve synergistic operation (Lal and Staelin 1984). This model require to cover all the key supply chain processes, including the master production schedule (MPS), material requirements planning (MRP), the procurement plan, subcontractor plans.

In accordance with the above requirements, proposed synergic quality management model in bags enterprise supply chain shown in Fig. 90.1.

During the model operation, you need to pay attention to the following aspects:

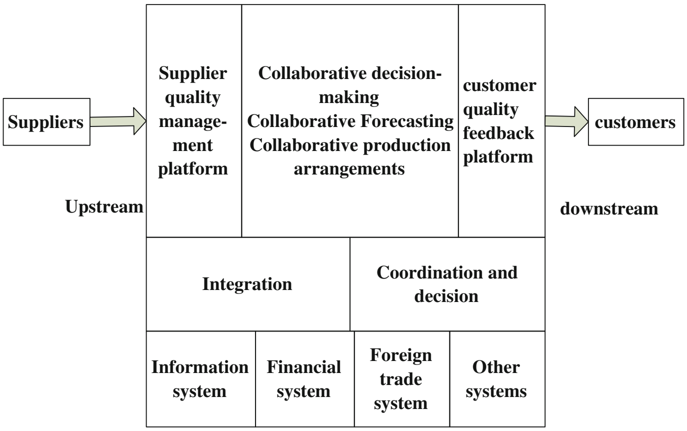

Fig. 90.1 Synergic quality management model in bags enterprise supply chain

(1) WWW service

WWW service for the supply chain is a typical three-tier structure, divided into customer service, supplier service two modules, allowing customers and suppliers to have access to supply chain system through the Internet, including registration, order generation, tracking orders for the implementation of the situation and forecasting information maintenance, and inventory information (Kohli and Park 1989).

(2) System management

System management subsystem used to maintain the system operation parameters and the underlying data set forecast parameters, customers/suppliers/institutions/warehouse/materials/personnel information such as password management, workflow process, which uses typical C/S structure (Starbird 1994).

(3) Task execution management

Task execution management includes storage task execution and inventory management, payment and collection of task execution and financial management, production task execution and production management, purchasing task execution and procurement management. It is also typical C/S structure.

(4) Coordination and decision center

Coordination and decision center includes the plan agent, coordinating agent, sales agent, purchasing agent, producing agent, inventory agent, and financial agent composed of orders (sales orders, purchase orders).

90.3.3 Other Recommendations

(1) Core enterprise should be more stronger and excellent: building supply chain management capacity

Core enterprise plays an important role in mutualism supply chain, it is the organizers and managers of the supply chain, it is also a supply chain innovator in collaborative system change, planners, promoters (Lira 2001). Therefore, we should vigorously develop the core enterprise in bags industry. To focus on the cultivation of core competitiveness, make the core enterprise become stronger and excellent. Core enterprise should focus on supply chain management, capacity building, so that enterprises can be armed with a powerful resource strength, market influence, coordination and management ability, social responsibility and innovative ability. It also includes a strong quality control capabilities and some market influence. Ultimately, the core enterprise supply chain management needs to promote the development of associated companies, to develop a symbiotic relationship with the affiliated companies, to ensure the quality control capabilities of the entire supply chain.

(2) Technical support of supply chain collaboration: technology standardization of the bags production

At present, Standardized production technology of bags products, which can be seen as an important technical support foe the enterprises and their suppliers to carry out supply chain collaboration, and it also can be seen as an important driving force for supply chain collaboration.

First, Standardized production technology of bags products encourage more suppliers to participate in quality management of the supply chain collaboration. Standardized production technology provide suppliers for simple, easy to learn, operational bags production technology and operating procedures, which will make suppliers providers luggage materials that meet market quality requirements. These measures will help overcome the short-term difficult in bags quality barriers.

Now we facing the situation that a large number of bags material supplied every year, but the quality are generally low. It is necessary for guiding the suppliers actively involved in the supply chain collaboration to produce bags products with higher-quality. During these processes, we should take technology standardization of the bags production as the measures, Use the role of the core enterprise and supplier of specialized cooperative organizations well. At the same time, we should build organizational forms like "Core business + bags suppliers + standardized production base" and make it an effective vehicle for the development of the luggage industry standardized production.

90.4 Discussion

It can be seen from the paper's findings that you should pay attention to the following aspects when you implement the bags enterprise supply chain collaborative quality control mechanism:

(1) Bags supply chain quality problems mainly come from Suppliers' product defects, non-standard production process and problems of physical and chemical properties.
(2) During the operation of synergic quality management model in bags enterprise supply chain, bags enterprise need to deal with WWW Service, System Management, Task Execution Management; Coordination and Decision Center.
(3) In order to improve supply chain collaborative quality control. Bags industrial clusters should build supply chain management capacity and provide technical support of supply chain collaboration.

90.5 Conclusion

Supply chain system's integrity and efficiency related to the level of the competitiveness of enterprises. Synergic quality management model in bags enterprise supply chain solve the existing problems in the quality control of bags business supply chain, and effectively integrate the procurement, sales, internal management. This paper use the idea of collaborative supply chain management to reorganization the company's internal production and management processes and provide efficient service to customers, which will make the bags companies directly facing the Business Process Management and improve the ability of providing service. This paper put forward bags supply chain collaborative quality control mechanism and operation method, which will be useful for improving the quality control of the bags enterprise supply chain.

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Chapter 91
Optimization of Recycling Network of Waste Mechanical and Electrical Products Based on GAHP

Wen-yong Zhou, Qing-yu Tian and Yun-fei He

Abstract Recycling network affects much the recycling efficiency of waste mechanical and electrical products (WMEP), but no uniform standard is in existence about how to choose a most suitable recycling network plan. Based on the research on the design and evaluation of recycling network, this paper establishes an evaluating index system of WMEP recycling network and uses the evaluation method GAHP to optimize it. Then a numerical example is used to prove its applicability. The value of this paper is that it complements the research on the optimization and index system of recycling network, is worth being extended to other fields.

Keywords GAHP · Optimization · Recycling network · WMEP

91.1 Introduction

The rationality of recycling network, which is the key ingredient of WMEP recycle, has a big effect on the efficiency of recycling. So choosing an appropriate recycling network scheme is to ensure the WMEP recycle operates efficiently (Achillas et al. 2010). However, difficulties often exist in the actual optimization process, which is often caused by the uncertainty reflected in the aspects of WMEP's quantity, damaged condition, treatment methods, recycle need and the cost of recycling and reprocessing (Chu and Song 2004).

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The research on optimization of WMEP recycling network is very few, which typically contains evaluation index system and optimization method. The paper (Wang et al. 2007) established an evaluation index system of recycling logistics with four-hierarchy tree structure, also provided the concrete explanation of evaluation index and advice of its application. The paper (Qian 2008) optimizes the logistics network of enterprise based on the endowing weight method of ANP. Evaluation method such as AHP, DEA, ANP are widely used for the optimization of recycling network in current research.

The problems and deficiencies in the existing research reflected in two aspects: one is that most research are around the establishment of evaluation index system, lack of specific research on optimization and evaluation; the other one is that most research based on the hypothesis that the amount of the recycling object is divinable and obeys some distribution regularity, that is discrepant with the truth. So on the basis of the paper (Xu and Wang 2010; Zhong et al. 2011) and research findings on the evaluation of recycling network and performance evaluation of logistics system, this paper will establish an evaluation index system of the recycling network according to the property of WMEP and use GAHP as the optimization method. The research findings of this paper complement the research on the optimization of recycling network and offer a new path for solving the optimization problem of uncertain system.

91.2 The Evaluation Index System of WMEP Recycling Network

The recycling network of WMEP is an organic whole consists of several interconnected and interacted elements, the performance of which reflects in the aspects of economy, technology, environment etc. and affected by them (Shuai et al. 2008). As a result, a reasonable evaluation index system and optimization method is necessary for evaluating its performance objectively and fairly.

Selecting the evaluation index is the primary and key step of the evaluation, which should obey the basic principle of systematic, measurable, simple, quantitative and qualitative (Chan et al. 2006). On the basis of the paper (Liu and Chen 2007; Sarkis 2003), we established an evaluation index system from three aspects: economy, society and environment, as well as five dimensionalities: conveniences, integration, environmental pollution, extendibility and economy. See Fig. 91.1.

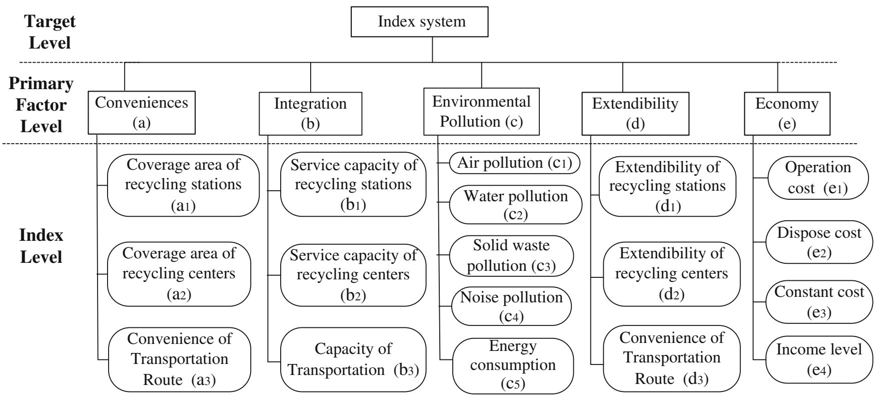

Fig. 91.1 Evaluation index system of WEMP recycling system

91.3 The Optimization Model and Calculation of Recycling Network

As the evaluation indexes differ a lot and many can't be described quantitatively, the application of traditional optimization method faces a lot of difficulties. The gray comprehensive evaluation method which can solve the problem of outcome bias caused by the uncertainty of the system, is a multidimensional gray evaluation method rooted in the Gray theory and based on the generation of whitening function (Kolodny et al. 2005). Compared with traditional weight distribution method, analytic hierarchy process (AHP) is more suitable for the multifactor evaluation as it can make the deciders' thought and decisions more numeric and systematized (Huo and Huang 2006). Therefore, we'll choose GAHP, the combination of gray comprehensive evaluation method and analytic hierarchy process as the optimization method.

91.3.1 Weight Distributing Process of AHP

According to the evaluation index system established in the foregoing chapter and AHP, we will calculate the weight matrix of indexes on the primary factor level which can be marked as $W = \left(W^a, W^b, W^c, W^d, W^e\right)$ and the index level, marked as $W^X = \left(W_1^X, W_2^X, \ldots, W_n^X\right)$, x = (a, b, c, d, e).

a. *Establish the determination matrix*

Quantificat the importance of each index according to the standard nine-point preference scoring system suggested by Saaty (2001) to establish the determination matrix.

b. *Get the weight matrix*

Step 1. Normalize every determination matrix:

$$b_{ij}^{x'} = \frac{b_{ij}^{x}}{\sqrt[n]{\prod_1^n b_{kj}^{x}}} \tag{91.1}$$

Step 2. Sum up the normalized numbers of the determination matrix by the row:

$$w_i^{(x')} = \sum_1^n b_{ik}^{x'} \tag{91.2}$$

Step 3. Normalize $w_i^{x'}$ and get the weight matrix W^x. W can be figured out in the same way.

$$w_i^{(x)} = w_i^{(x')} / \sum_1^n w_k^{x'} \tag{91.3}$$

91.3.2 Evaluating Process of Gray Comprehensive Evaluation Method

Step 1. Determine the grade system of all the indexes on the index level according to the industry standard, historical data, decision makers' experience and preference.

Step 2. Organize experts to grade the indexes on the index level of all recycling network scheme, the quantity of which is t(t = 1, 2,…,n), based on the grade standard and then get the evaluation sample matrix D.

Step 3. Let e(e = 1, 2,…, g) represents the serial number of gray-grade of evaluation. Establish whitening function based on the grade system and figure out the gray-grade of each index.

Step 4. Let y_{ie}^{xt} represents the gray-grade coefficient of the grade of index x_i which belongs to the gray-grade of evaluation with the serial number e.

$$y_i^x t = \sum_1^g y_{ie}^{xt} \tag{91.4}$$

Step 5. Let r_{ie}^{xt} represents the weight of x_i that belongs to the recycling network "t", which is relegated to gray-grade "e" by experts and get the weight matrix of the gray evaluation R_x^t:

$$r_{ie}^{xt} = y_{ie}^{xt} / y_i^{xt} \tag{91.5}$$

Step 6. Calculate the synthetical weight vector of the gray evaluation of recycling network "t" based on R^t, which is represented as:

$$Z^t = W \cdot R^t \tag{91.6}$$

Step 7. Assign each gray-grade by grade levels to generate the equating vector $\mathrm{H} = \left(\mathrm{h}_1, \mathrm{h}_2, \ldots, \mathrm{h}_g\right)$, on the basis of which we can get the synthetical evaluation value of the recycling network "t".

$$v^t = Z^t \cdot H^T \tag{91.7}$$

So we can figure out the synthetical evaluation vector $\mathrm{V} = [\mathrm{v}^1, \mathrm{v}^2, \ldots, \mathrm{v}^{\mathrm{t}}]$ of all recycling networks.

According to V, we can get the evaluation grades of all the recycling network schemes to judge their rationality and choose the most suitable scheme.

91.4 A Numerical Example

One recycling corporate came up with 5 feasible schemes of constructing recycling network. The optimization process based on the model of GAHP introduced in the forgoing chapter is as follows.

Step 1. Figure out the weight of each index according to the basic model of AHP and formula 91.1–91.4. If the uniformity check is passed, we can get the weight vector W and W^{x} as follows:

$$\begin{aligned} W &= [0.129, 0.065, 0.258, 0.032, 0.516] \\ W^a &= [0.444, 0.444, 0.111] \\ W^b &= [0.286, 0.571, 0.143] \\ W^c &= [0.133, 0.044, 0.531, 0.027, 0.265] \\ W^d &= [0.286, 0.143, 0.571] \\ W^e &= [0.279, 0.093, 0.0700.558] \end{aligned}$$

Step 2. Determine the grade system shown in Table 91.1 based on the 5-point method (Xu et al. 2007).

Step 3. Organize experts to grade the index e x_{i} according to the Table 91.1. For the contrary indexes like cost and pollution, the grade should obey the reversed principle. The sample matrix of evaluation D is:

Table 91.1 Grade system

Grade	5.0–4.0	4.0–3.0	3.0–2.0	2.0–0.0
Evaluation index: X_{i}	Excellent	Good	General	Bad

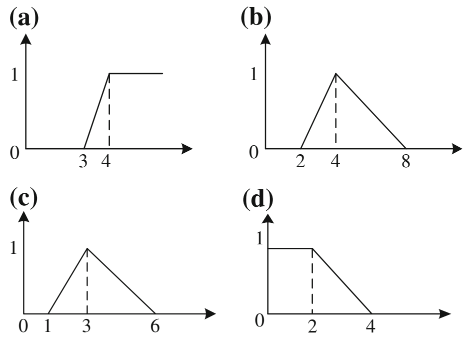

Fig. 91.2 The whitening function

$$D = \begin{bmatrix} 4 & 5 & 3 & 4 & 3 & 5 & 4 & 3 & 3 & 2 & 4 & 5 & 5 & 2 & 3 & 2 & 4 & 4 \\ 5 & 5 & 4 & 2 & 3 & 4 & 3 & 2 & 2 & 2 & 5 & 5 & 3 & 2 & 3 & 4 & 4 & 4 \\ 5 & 5 & 4 & 2 & 3 & 5 & 4 & 2 & 3 & 2 & 5 & 5 & 3 & 3 & 4 & 4 & 4 & 4 \\ 4 & 5 & 5 & 3 & 3 & 4 & 4 & 2 & 2 & 3 & 4 & 5 & 3 & 4 & 4 & 4 & 4 & 4 \\ 5 & 5 & 4 & 4 & 4 & 5 & 3 & 3 & 4 & 3 & 5 & 5 & 4 & 3 & 4 & 3 & 4 & 4 \end{bmatrix}$$

Step 4. Confirm four gray-grades of evaluation, choose four gray levels and establish whitening function using construction method of trigonometric endpoint type (Dong et al. 2010). The whitening function is as follows (Fig. 91.2):

Step 5. Calculate the weight vector of the gray evaluation of the whole index system in the 5 recycling networks based on the formula 91.4 to 91.6, the result is as follows.

$$Z^a = [0.227, 0.303, 0.335, 0.135]$$
$$Z^b = [0.241, 0.273, 0.304, 0.183]$$
$$Z^c = [0.309, 0.334, 0.284, 0.074]$$
$$Z^d = [0.303, 0.310, 0.272, 0.116]$$
$$Z^e = [0.352, 0.357, 0.262, 0.030]$$

Assign each gray-grade by grade levels shown in Table 91.1, we can figure out $H = [5, 4, 3, 2]$.

Besides, we can figure out the synthetical evaluation vector $V = [3.623, 3.571, 3.877, 3.800, 4.030]$.

The result shows that the highest grade is the fifth scheme, 4.030 and prove the effectiveness of this model for the result agrees with the actual situation.

91.5 Conclusion

The optimization of recycling network is a complex job as its uncertainty may lead to the result deviation. While the GAHP model can solve these problems for its property of multilevel and multifactor and also reduce the subjective influence from experts. This paper establishes an evaluation index system of WEMP recycling network based on the principle of measurable, simple, etc. and practices GAHP, which is of good maneuverability and promotional value, in a numerical example. However, there are some shortages in this paper need to be improved in further research, which reflected in that the optimization model depends much on the experts' judgment, which may affect the conclusion subjectively.

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Chapter 92
Does Quality Management Support Innovation? A Resource-Based View

Yong-tao Song and Xiu-hao Ding

Abstract Based on the resource-based view, this paper develops a conceptual model incorporating quality management practice, R&D capability, innovation, and firm performance. A questionnaire survey is conducted to examine the hypotheses. The results indicate that quality management practice has a significant positive influence on innovation through the mediating effect of R&D capability. Moreover, the positive influences of R&D and innovation on firm performance are supported. This paper identifies the influencing mechanism between quality management and innovation, and contributes to the quality management theory.

Keywords Quality management practice · Innovation · R&D capability · Resource-based view

92.1 Introduction

With the trend of intensive competition and shortening product life-cycle (Bayus 1994), firms realize the significant importance of product/service innovation. In such a case, innovation has been widely accepted, researched and paid more and more attention by scholars and practitioners as a strategic tool, and a plenty of studies investigated how to improve innovation efficiency and to increase innovation outputs. In parallel with the development of quality management and the significant role it plays in improving product quality and promoting firm

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performance, scholars and firms anchored their hops on quality management to improve innovation, and a lot of studies began to explore the influence of quality management on innovation. However, the research related to the quality management in innovation/research and development (R&D) activities is just a beginning, and extant studies on quality management in innovation/R&D are mainly concentrating the concept of quality in innovation, case studies of successful quality in innovation activities, and quality management framework in innovation process (Kumar and Boyle 2001), etc. The relationship between quality management and innovation, and how to execute quality management in innovation process is still unclear.

Anecdotal evidence suggests that the effect of quality management looks obvious in manufacturing process, yet proves ineffective in innovation activities. Both the senior managers and the first-line staffs did not understand how to execute quality management in innovation process. A review of the studies conducted on quality management in innovation activities reveals that there are few studies examine the relationship between quality management and innovation, and what is more important is that most of these studies focus on the influence of quality management on innovation results, e.g. product innovation (Prajogo and Sohal 2003, 2006; Martínez-Costa and Martínez-Lorente 2008), process innovation (Prajogo and Sohal 2003, 2006; Martínez-Costa and Martínez-Lorente 2008), technological innovation (Santos-Vijande and Álvarez-González 2007; Abrunhosa and Sá 2008), or administrative innovation (Santos-Vijande and Álvarez-González 2007), and the influence mechanism of quality management on innovation is neglected. Moreover, there are conflicting conclusions in existing researches. Some scholars state that quality management fosters innovation (Prajogo and Sohal 2003), and other studies reveal that quality management hinders quality (Prajogo and Sohal 2006). Therefore, it is reasonable to conclude that the ambiguous influence mechanism of quality management on innovation is the main reason of existing conflicting results.

In reality, quality management is composed of various elements and innovation is also a multidimensional phenomenon. The impact of quality management on innovation depends both on the specific elements of quality management and the type of innovation (Abrunhosa and Sá 2008). Up to now, little is known about how quality management influence innovation and it is difficult to estimate the influence of quality management on innovation accurately.

Clarifying the effects of quality management on innovation can not only guide firms' innovation practices, but also enrich quality management theory and innovation theory through expanding the applying scope of quality management. Therefore, this study aims to investigate the mechanism that quality management influences innovation. Specifically, this study wants to know the paths through which quality management influences innovation. Thus, this study introduces the term of R&D capability based on resource-based view, and investigates the mechanism quality management capability influencing innovation through analyzing the relations among quality management practice, R&D capability, and innovation.

92.2 Theoretical Framework and Hypotheses

92.2.1 Theoretical Background

Prior empirical studies show that the implementation of quality management in manufacturing or servicing can improve quality performance and firm performance (Powell 1995; Kaynak 2003; Tarí et al. 2007). There are abundant studies on quality management theory (Sitkin et al. 1994), firm quality management system construction (Zhao et al. 2004), quality management practice (Powell 1995) and relationship between quality management and performance (Powell 1995; Kaynak 2003; Tarí et al. 2007). However, few studies investigate quality management in the innovation background. Prior scholars argue that quality management stresses rules and standardizations and limits its application in innovation activities (Jayawarna and Pearson 2001). However, with the development of quality management theory, some practices and tools of quality management have been widely applied in innovation activities, such as new product development and R&D. For example, the involvement of people and teamwork of quality management are consistent with the cross-functional team in NPD and/or R&D, and customer focus of quality management is consistent with customer participation in NPD, and quality function deployment is applied widely in customer need survey in innovation activities.

Nowadays, innovation has changed from technology-driven to multifactor-driven (including technology and market) behaviors, and just relying advanced technology can not guarantee that the innovation fruits meet the requirements of customers/market. In addition, technology advancement and diffusion makes it is almost impossible for firms to form core capabilities relying one technology. As a result, it is necessary for firms to integrate innovation, which is supported by technology, and quality management, which is based on customer/market and production, to ensure innovation going smoothly. Although there are growing calls to apply quality management to NPD, and scholars have made great efforts to do this, it is unpractical to apply manufacturing-based quality management theory, practices, and technologies to NPD process directly. First, quality management and innovation have different theoretical bases, which make them conflict sometimes. Second, the relationship between quality management and performance in traditional manufacturing process will change in innovation environments. Quality management improves performance through quality or efficiency improvement in manufacturing process, while it will affect performance through R&D capability improvement in innovation environments. Therefore, it is necessary to clarify the mechanism that quality management influences firm performance with the purpose of applying quality management in innovation activities effectively.

Meanwhile, although quality management has developed for almost 100 years since 1920s, it has not formed a widely accepted, formal and integrated theory. Academy of Management Review discussed quality management in 1990s, and scholars such as Sitkin et al. (1994) explored how to develop quality management theory in virtue of existing management theories. On this basis, Sousa and Voss (2002) and Schroeder et al. (2005) put forward that existing management theories (for example, contingency theory and institution-based theory) can be employed to improve quality management theory.

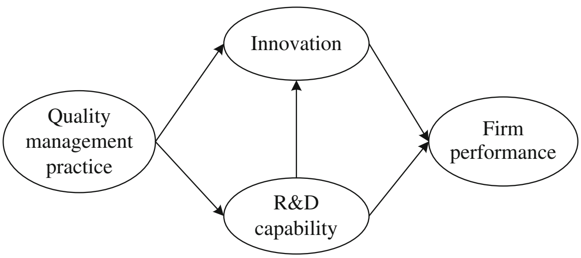
This study introduces the term of R&D capability based on resource-based view and takes quality management as inimitable resources forming dynamic capability. According to capability-based theory, firms' capabilities are not endowed when born and can not be bought in market, and they are created through environment adaption and resource acquisition and configuration. Quality management is a method to gain competitive advantage, and creates conditions for firms to adapt environment and acquire and configure resources. Introducing R&D capability, this study can explain how quality management influence innovation and consummate quality management theory.

92.2.2 Hypotheses

On the basis of literature review, this study puts forward the conceptual model in Fig. 92.1, which links quality management practice, R&D capability, innovation and firm performance. We attempt to analyze the relationships among these variables to clarify the paths that quality management influencing innovation and how quality management contributes to firm performance in the innovation environments.

The focus of innovation is improvement of processes (Terziovski 2010). Thus, quality management, whose principle is continuous improvement of processes, will promote innovations. Existing studies also suggest that quality management has a positive effect on innovation (Prajogo and Sohal 2003; Abrunhosa and Sá 2008), because some elements of quality management, especially basic quality management practice and software quality management, can promote innovation. Santos-Vijande and Álvarez-González (2007) find that Total Quality Management (TQM) has significant positive effects on innovation culture and management innovation. Although the effects of TQM on innovation may change in different

Fig. 92.1 Conceptual model



conditions or environments, TQM is always the resources supporting and cultivating innovation. Therefore, this study proposes:

H1: Quality management practice has a positive effect on firm innovation.

Existing studies argue that quality management promotes innovation, but they do not explore the paths and mechanisms that quality management influences innovation. This study introduces the term of R&D capability based on resource-based view to clarify the effect of quality management on innovation. There is not a widely accepted definition of R&D capability, and scholars also use different terms. Su et al. (2009) use R&D capability, and Ettlie and Reza (1992) use new product dynamic capability, and Huang and Chu (2010) use product development capability. If firms want to succeed in innovations, they should have R&D capabilities. Quality management practice, which is valuable and inimitable, pushes firms to construct their R&D capabilities. R&D capability affects product and process innovation directly. Furthermore, because R&D capability reflects firms' capabilities to produce science discoveries and technological breakthrough, it determines firm innovation performance in a large part. Therefore, we have the following hypothesis:

H2: Quality management practice positively affects firm innovation through R&D capability.

R&D capability can not only promote firm innovation but also influence firm performance positively. As innovation is becoming more and more import in the economy, firms' successes are more and more dependent on innovation performance, which is determined by R&D capability. Existing studies also confirm that R&D capability has significant effect on firm performance. For example, Zaheer and Bell (2005) find that innovation capability improves firm performance based on Canadian security companies, and the empirical results of Ettlie and Pavlou (2006) also suggest that new product development capability positively affects new product performance and firm performance. Thus, we have the following hypothesis:

H3: R&D capability has a positive effect on firm performance.

In the literature about innovation, the influence of innovation on firm performance receives a lot of attention. Some studies explore the relationship between innovation and firm performance from the perspective of innovation motivation, and argue that innovation has significant positive effect on firm performance. The reason is that unique innovative products, services and processes contribute to firms' differentiation strategies, and provide firms sustainable competitive advantages. Then, firms can surpass competitors and increase sales and profits. Therefore, this study puts forward:

H4: Firm innovation positively influences firm performance directly.

92.3 Methodology

92.3.1 Research Setting

This study sends the copies of questionnaires to firms that have obtained quality management system certification with the help of China National Institute of Standardization, which have well-developed management bases and abundant management experiences. We sent questionnaires to directors of R&D or quality management department of 300 firms using mail or email. The data collection process lasted about 2 months. In order to increase the recovery rate of questionnaire, we promised that we would provide the research findings to the survey firms. Meanwhile, we maintained full anonymity for all informants throughout the survey process, and informed the respondents that the survey was designed for research only and there were no wrong or right answers to our questions in our cover guide (Podsakoff et al. 2003).

One month after sending the questionnaires, we reminded the respondents that had not completed the questionnaires using mail or telephone. When the survey finished, a total of 198 usable questionnaires were achieved after we removed the incomplete questionnaires with missing data or doubt answers, constituting a 66 percent response rate.

92.3.2 Analysis and Findings

A confirmatory factor (CFA) approach is used to test the common method bias. A model positing that a single factor underlies the study variables is assessed by linking all items of the dependent and independent variables to a single factor. The results show that one-factor model is not acceptable and common method bias did not pose a serious threat to interpretation of the subsequent analyses in this study (Podsakoff et al. 2003).

Reliability is assessed using the internal consistency method via Cronbach's alpha. All of the four latent constructs, with the exception of R&D capability (0.698), have Cronbach alphas of more than 0.7. These results indicate that all scales demonstrated good reliability (O'Leary-Kelly and Vokurka 1999).

Convergent validity was assessed from the measurement model by determining whether each indicator's estimated pattern coefficient on its hypothesized underlying construct factor is significant (greater than twice of its standard error), and discriminant validity was assessed from the measurement model by determining whether all confidence intervals ($\pm$ two standard errors) around the correlation estimate between two factors did not include 1.0. The result provides strong evidence of convergent validity and discriminant validity (as shown in Table 92.1).

Table 92.1 Correlative coefficient and standard error

	1	2	3	4
Quality management practice	1.00			
Innovation capability	0.77(0.04)	1.00		
Innovation	0.72(0.04)	0.80(0.04)	1.00	
Firm performance	0.63(0.05)	0.65(0.05)	0.67(0.04)	1.00

Note The numbers in the brackets are the standard errors

Table 92.2 Results of structural model

Hypotheses	Path	Standardized loading	T value	Result
H1	Quality management practice → Innovation	0.22	1.90	Reject
H2	Quality management practice → R&D capability	0.79	8.78	Supported
	R&D capability → Innovation	0.64	4.84	
H3	R&D capability → Innovation	0.40	3.05	Supported
H4	Innovation → Firm performance	0.35	2.81	Supported

The following fit statistics were obtained for the structural model: Chi square (x^2) = 638.90, degrees of freedom (*df*) = 270, Root Mean Square Error of Approximation (RMSEA) = 0.083, Comparative Fit Index (CFI) = 0.97, Non-Normed Fit Index (NNFI) = 0.97, Goodness-of-Fit Index (GFI) = 0.79, and Root Mean Square Residual (RMR) = 0.058. The standardized loadings (γ), standardized errors, and t-values are shown in Table 92.2. All of the standardized loadings were high ($\gamma > 0.20$) and significant ($t > 1.96$). The results thus provided empirical support for Hypothesis 2, Hypothesis 3, and Hypothesis 4.

92.4 Discussion and Implications

92.4.1 Main Finding

Several interesting findings can be drawn form this study. First, this study finds that quality management practices do not significantly influence firm innovation directly, but indirectly through the mediating effect of R&D capability. Second, this study finds that R&D capability and firm innovation positively influence firm performance, which is consistent with early empirical studies.

92.4.2 Managerial Implications

The first managerial implication to be drawn from the results is that innovation is influenced by many factors, but is mostly determined by R&D capability. Quality management can not guarantee innovation performance solely, and some elements of quality management even restrain innovation. For example, quality management emphasizes the reduction of variances to enhance process stability. However, because of the nonrepeatability and uncertainty of innovation, it is no use to improve the reliability and stability of the process through reduction of process variation. Moreover, innovative ideas of product emerge when there is variation in organizational process, when something different and untried is pursued (Sethi and Sethi 2009). Thus, the reduction of variations will limit the sources of new product ideas.

The second managerial implication is about the relationship between quality management and R&D capability. Although quality management is widely diffused and applied in the world, a lot of contents of quality management are difficult to imitate (Powell 1995), especially the soft elements such as leadership, quality strategy, and quality culture. Firms can use these inimitable quality management elements to construct firms' core capabilities and competitive advantages. Therefore, quality management capability can promote firm innovation through R&D capability. This finding clarifies the mechanism that quality management influences firm innovation, and can explain the inconsistency in existing studies. More recently, some studies have realized that the relationship between quality management and innovation is complex. They suggest that quality management and innovation are dynamic capabilities based on learning, improvement and revolution (López-Mielgo et al. 2009), and these two capabilities complement each other. Although quality management influences R&D capability positively, we should recognize that the effect is limited. Benner and Tushman (2003) have found that TQM contributes to exploitation capability but do not to exploration capability. Thus, when firms create their R&D capability, they should make full use of all kinds of resources (López-Mielgo et al. 2009).

Third, prior studies have confirm that firms' specific and inimitable elements can strengthen their R&D capability, which will contribute to firm performance (Zaheer and Bell 2005). Moreover, studies on innovation have also confirmed the direct and indirect influences of innovation on firm performance. Therefore, firm can integrate quality management practice and other practices to construct R&D capability, and use R&D capability to promote innovation and improve firm performance.

92.5 Limitations and Future Research

This study discusses the relationships among quality management practice, R&D capability, firm innovation and firm performance, and clarifies the mechanism that quality management influences firm innovation, which can explain the inconsistency in existing studies. However, quality management practice consists of many elements and is a multi-dimension variable, and there are different types of innovations (for example, incremental and radical innovation, and/or product innovation, process innovation, and management innovation, but this study does not explore the effects of quality management elements on different types of innovations. Thus, it is valuable to investigate how quality management elements influence different types of innovations.

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Chapter 93
Signaling Game Model of Safety Management on Construction

Hong Ren and Fei Xu

Abstract Our paper explores the association between Supervisors and construction enterprises in construction Safety supervision. Specifically, the behaviors between supervisor and construction enterprise were analyzed by using the game theory. Then related factors influencing construction safety were identified, dynamic signaling game is studied. Based on the multi-hierarchy organization analysis, a signaling game-theoretic model was developed to inspect collusion and incentive mechanism on construction safety. Related proposals were put forward (Ahmed and Hegazi 2005).

Keywords Constructions safety control · Dynamic multi-team game · Signaling game · Asymmetric information

93.1 Introduction

As noted consistently over the past three decades in professional construction association publications, and safety Progress, Chinese organizations have increasingly focused on continuously improving the safety of the construction. In the Safety of the construction management process, asymmetric information exists between safety supervisors and contractors about the Safety of real estate development, the supervisors can not accurately obtain the contractor's behavior choices and level of effort on construction safety; the level of contractor management, Safety management systems, financial policy, the future operation of other factors which affect future constructions level of Safety. Supervisors do not understand the information accurately, contractors can understanding of the structure of the performance of building materials, the building better, engineering

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and technical programs, construction design, as well as a variety of solutions and Safety standards, the contractor knows best whether they have requirements consistent with the construction engineering skills, but also most clearly engaged in engineering construction, physical, financial and other processes, which means that the contractor know more information than supervisors, which means the Safety of the information asymmetries. Then, the theory of game theory, signaling game model can show the contractor true Safety management level in the construction Safety management.

93.2 The Model

93.2.1 Literature Review

Helander (1991) analyzes statistics of fatalities and injuries in construction work. Found that the cost of construction accidents amounts to about 6 % of total building costs. Rafiq M. Choudhry and Dongping Fang research aimed at why construction workers engage in unsafe behavior. Li et al. (2009) analyzes the competitive advantage of the construction enterprise in the view of safety in China. Ye et al. (2011) analyze the factors influencing construction safety by using a Fuzzy Factor Analysis Model (FFAM). Eight common factors are obtained by using the developed FFAM, and suggested Measures to lower safety cost. Deng Shu-fen et al. established a signaling model between food producer and the consumer. Jeffrey Banks et al. finds that most choices by both players are part of some Nash equilibrium, but deviations from equilibrium behavior occur when the choices are part of different equilibrium (Rivara and Thompson 2000).

The present paper explores the construction safety in a signaling game experiment. It has long been known that signaling games often yield a bewildering profusion of sequential equilibrium. This has led theorists to devise numerous refinements for limiting the set of sequential equilibrium (Rivara and Thompson 2000).

Brandts and Holt's experiments have demonstrated that subjects tend to follow simple, history dependent learning processes and, with the right game structure, can be induced into violating even the simplest of equilibrium refinements (Cooper 2003; Cooper and Kagel 2009; Mailath 1993). Kaya (2009) analyze a class of repeated signaling games in which the informed player's type is persistent and the history of actions is perfectly observable. Cooper and Kagel (2009) study find that teams are shown to violate the most basic of equilibrium refinements in signaling games: single-round deletion of dominated strategies (part of the Cho–Kreps intuitive criteria).

Our signaling game model is based on Zhuang and Bier (2011) model and reference of Ren and Yang (2010) research work and takes separating equilibrium and pooling equilibrium into consideration. It is regarded that separating equilibrium can differentiate enterprises, and there is no collaborative actions. However, pooling equilibrium cannot differentiate enterprises, and it is highly possible for the collaborative actions. In view of these, this study selects Signaling Game model to analyze the collaborative mechanism of supervisors and construction enterprises.

93.2.2 Framework of Signaling Model and Hypothesis

Game theory (Zhang 2004) is an important approach to study complex adaptive systems. Our game has two players: 1 represents construction enterprises, and 2 is supervisor of construction Safety. The sender has some private information about an event that is chosen by nature according to some fixed probability distribution from the set of events. The sender makes the first move by emitting a signal from some set that can be observed by the receiver (Jäger 2008). Our model involves a N-period game with private information (Parlour et al. 2007).

E means the type space of participant 1. This is private information, and participant 1 knows the value of E. $E = E_1$ represents that construction enterprises are qualified. $E = E_2$ represents construction enterprises are not qualified. Participant 2 only know its probability distribution $P\{E = E_1\} = p, \quad P\{E = E_2\} = 1 - p$.

M means the signal space of participant 1. Supposed that the construction technology of enterprises is similar, construction cost can give us a signal whether the construction Safety of enterprises is qualified or not. Further supposed that the construction cost of enterprises E_1 is C_1, that of enterprises E_2 is C_2, and $0 < C_2 < C_1$. Then, $M = M_1$ represents the reported construction cost C_1 of enterprises, $M = M_2$ represents the reported construction cost C_2 of enterprises. If a construction enterprise is the type of E_2, but the reported construction cost is C_1. Then, it is thought that that construction enterprise tells lie.

A means the action space of participant 2. After receiving reported construction information of enterprises, construction supervisors will check the construction Safety by themselves. $a = a_1$ represents that supervisors take active measures to check the real conditions of construction Safety. $a = a_2$ represents that supervisors take negative supervision measures, and they trust the reported information of construction enterprises, even if such enterprises tell lies. The costs of these two supervision actions are C_1 and C_2 respectively, and $0 < C_1 < C_2$.

When $E = E_1$, it is certain that $M = M_1$, i.e. construction enterprises with qualified construction can not claim that there is something problematic with themselves.

Real estate developer will punish the construction enterprises with wrong reported information and with unqualified Safety. The penalties are T_0 and T. When there are problems with construction constructions, enterprises may buy off supervisors W to make them take negative actions. In order to strengthen supervision, real estate developer regulate that supervisors can gain B of penalty as bonus.

93.2.3 Model

Through Harsany transfer, suppositional participant N (Nature) is introduced to decide the type of construction enterprises. After ascertaining their own types, construction enterprises choose the signal $M \in M$. Once getting the signal M from construction enterprises, supervisors, by using Bayesian Principle, gain posterior probability $p\sim = p\sim(E\,|\,M)$ from prior probability $P = P(E)$, then choose the action $a \in A$.

$I_i(E, M, \alpha)$ represents income equations of participant $(=1, 2)$, based on the preceding assumption:

$$I_1(E_1, M_1, \alpha_1) = -C_1; I_1(E_1, M_1, \alpha_2) = -C_1;$$

$$I_2(E_1, M_1, \alpha_1) = -C_1; I_1(E_1, M_1\alpha_2) = -C_2;$$

$$I_1(E_2, M_2, \alpha_1) = -C_1 - T; I_1(E_2, M_2, \alpha_2) = -C_2 - T;$$

$$I_2(E_2, M_2, \alpha_1) = -C_1; I_2(E_2, M_2, \alpha_2) = -C_2;$$

$$I_1(E_2, M_1, \alpha_1) = -C_2 - T - T_0; I_1(E_2, M_1, \alpha_2) = -C_1 - W;$$

$$I_2(E_2, M_1, \alpha_1) = -C_1 + BT + BT_0; I_2(E_2, M_1, \alpha_2) = -C_2 + W$$

In this model, it is uncertain of pooling equilibrium (M_1, M_1) or separating equilibrium (M_1, M_2). That is to say, the construction enterprises with the types of E_1 and E_2 both choose the action M_1, or the type E_1 enterprises choose action M_1 and the type E_2 enterprises choose action M_2.

(1) Pooling equilibrium (M_1, M_1). When supervisors get the signal M_1, they cannot acquire any additional information about construction enterprises, apart from prior probability. Therefore, posterior probability equal to prior probability, i.e.

$$p\sim(E_1|\,M_1) = p,\ p_2\sim(E_2|\,M_1) = 1 - p$$

Their expectation payment is $-C_1p + (-C_1 + BT + T_0B) * (1 - p)$ when supervisors choose the action a_1. Their expectation payment is $-C_2p + (-C_2 + W) * (1 - p)$ when supervisors choose the action a_2.

Thus, when $-C_1p + (C_1 + BT + T_0B) * (1 - p) > -C_2p + (-C_2 + W)* (1 - p)$, i.e. $C_1 - C_2 < (BT + T_0B - W) * (1 - p)$, supervisors will choose the action of a_1, otherwise, a_2 is chosen.

When supervisors get the signal M_2, in this non-equilibrium condition, $p_2^{\sim}(E_2|\,M_2) = 1$. Because $0 < C_2 < C_1$, construction supervisors will choose action a_2 inevitably. At this time, there is no different for E_1 type construction enterprises with the action M_1 or M_2, E_2 type construction enterprises will choose action M_1 under the condition of

$$C_1 - C_2 > (BT + BT_0 - W) * (1 - p);$$
$$-C_1 - W > -C_2 - T$$

Combining the above two equations together, it is

$$[(C_1 - C_2)/(1 - p) + W]/B - T_0 > T > C_1 - C_2 + W \quad (93.1)$$

That is to say, pooling equilibrium (M_1, M_1) emerges when Eq. 93.1 is valid.

(2) Separating equilibrium (M_1, M_1). In equilibrium condition, when supervisors get the signal M_1 and M_2, they will choose action a_2.
Facing supervisors' possible choice, there is no difference for E_1 type construction enterprises with the action M_1 or M_2, E_2 type construction enterprises will choose action M_2 under the condition of

$$-C_1 - W < -C_2 - T, \text{ i.e.}$$
$$T < C_1 - C_2 + W \quad (93.2)$$

Separating equilibrium (M_1, M_1) emerges while Eq. 93.2 is valid.

93.3 Results

Based on the above research, it is found that separating equilibrium and pooling equilibrium both exist under certain extents and these two extents are not intersect ant. There is no collaborative action in separating equilibrium, but in pooling equilibrium. Therefore, collaborative actions can be eliminated while breading pooling equilibrium, and reducing the extent of pooling equilibrium means decrease of collaborative actions (Holt and Sherman 1994). The analysis of possibility of pooling equilibrium and their changes in equilibrium extent is helpful for understanding collaborative action.

According to Eqs. 93.1 and 93.2, it can be found that:

(1) Construction supervisors both take negative supervision actions in separating equilibrium and pooling equilibrium. Based on Eq. 93.1, the decrease of $C_1 - C_2$ will lead to decrease of pooling equilibrium extent. Extremely, when $C_2 = 0$, the decrease of C_1 will lead to decrease of pooling equilibrium extent. That means the decrease of action supervision cost can reduce pooling equilibrium extent. Supervisors will make active examination when cost is decreased to certain level, and pooling equilibrium is broken.

(2) According to Eq. 93.1:
$B < [(C_1 - C_2)/(1 - p) + H]/(T + T_0)$, this model means that the bonus cannot play the role of motivating to supervisors when bonus B is less than $[(C_1 - C_2)/(1 - p) + W]/(T + T_0)$. Under this situation, the equilibrium

result is that construction enterprises provide mendacious information and construction supervisors take negative actions to supervise. Conversely, they will take active actions to supervise and pooling equilibrium is broken. Thus, increasing the reward of construction supervisors is helpful to reduce the collaborative actions between supervisors and enterprises.

(3) It can be found from Eq. 93.2 that there is separating equilibrium when penalty is less than $C_1 - C_2 + W$. At this time, construction enterprises do not provide false information, even if the construction Safety is unqualified. However, this kind of penalty is useless for enterprise. Therefore, construction Safety cannot improve. $C = 0$ in Eq. 93.2 has illustrate this point.
(4) When W decrease, the extent of separating equilibrium will decrease and that of pooling equilibrium will increase correspondingly. Thus, the decrease of bribe makes construction enterprise conducting illegal operation.
(5) When rate of qualified construction is low, penalty to some extent can break pooling equilibrium. While the rate is very high, pooling equilibrium can be broken as penalty approaches infinity.

93.4 Discussion

93.4.1 Construction Enterprises' Actions for Safety

Construction enterprises depress the Safety of construction to gain more profit. This situation cannot be improved by penalty. The separating equilibrium in the above model can explain this phenomenon. In this situation, there are many construction enterprises with Safety problems, although no collaborative action is occurred between supervisors and construction enterprises.

93.4.2 Collaborative Mechanism Analysis

Once the penalty to the construction enterprise with unqualified constructions increases there is collaborative action between supervisors and enterprises by comparing the Eqs. 93.1 and 93.2. Therefore, real estate investors try to decrease the chance of illegal collaborative actions between supervisors and enterprises, when they plan to punish the enterprises with unqualified constructions.

Under the current management system, investors of real estate constructions cannot manage construction enterprise directly. The management to construction enterprises is achieved by professional Safety supervisors. As the agent of real estate investors, it is possible for Safety controllers to gain maximum benefit with minimum cost during the supervision process. According to the Eqs. 93.1 and 93.2 in Sect. 93.2.3, increasing the reward to Safety controllers and decreasing the supervision cost are both able to reduce collaboration. According to the Eq. 93.1 in Sect. 93.2.3, when the rate of qualified construction Safety is very low, the punishment on construction enterprises to certain extent can break pooling equilibrium. While the rate of qualified construction safety is high, the penalty T of construction enterprises approaches infinity to break equilibrium. Under the high rate of qualified construction, construction supervisors are highly possible to take negative supervision measures for the consideration of saving cost. Thus, it is more difficult to identify the construction enterprises with qualify problems. However, constructions enterprises will choose improve construction safety when penalty T approaches infinity.

93.5 Conclusion

93.5.1 Strengthening Supervision and Stimulation

Rent-seeking of supervisors may lead to failure of supervision. In order to increase the effectiveness of construction Safety control, more requirements are needed for supervision organizations, such as increase the transparency of supervision and more involvement of media supervision. Also, appropriate stimulation mechanism is needed to stimulate supervision organization to supervise the construction Safety on time and effectively.

93.5.2 Using Construction Safety to Assess the Organizations Involved in Construction Management

The tool of Safety assessment for managers of construction enterprises should be utilized. Construction supervision institution can add construction Safety into the assessment indicators for managers of construction enterprises. Therefore, it can promote construction management organizations to set up the short-dated and long-dated targets based on the current situation of construction Safety. Thus, these targets can be used to assess the performance of construction managers.

93.5.3 Increasing Social Responsibility of Construction Enterprises

Better construction Safety is not only the requirement of state and society, but also the social responsibility of construction enterprises. Construction enterprises, as the direct construction Safety manager, should develop based on the good construction Safety. On the one hand, they should strengthen the awareness of construction Safety, and regard the construction Safety as an important content of competitiveness and social responsibility. On the other hand, they should input more on R&D, develop and apply the advanced and energy-efficient construction technology, and prefer the energy-efficient and low-polluted materials, technology and equipment promoted by the state and industry.

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Chapter 94
Research of On-Line Quality Management System for Filter Tips Based on MES

Yue Zhang, Kai-chao Yu and Wei-ping Zhang

Abstract Combined with the quality management requirements, the article took the quality management in the productive process of filter tips in tobacco enterprises as a research object. And it analyzes the filter tips process and common quality problems, and then proposes a quality management system for filter tips based on MES. Afterwards it discusses the system requirements, the quality control model, functional model and key technologies. Finally, the visual, real-time and dynamic quality management in the productive process of filter tips are realized.

Keywords Filter tips · MES · Quality management · System

94.1 Introduction

Quality is the eternal theme of enterprises, and is also to achieve sustainable development, to win the victory in the next competition, more importantly, and it is the key to improving efficiency way (Gong 2009).

IT can promote the modernization of cigarette production and quality management, and it is an effective way to improve overall competitiveness of the cigarette industry. At present, in the tobacco enterprises, the management information system and automation technology have large-scale application (Hu 2004). But ignoring the effective co-ordination between them, it leads to enterprises upper plans lack the effective real-time information support and the lower levels are lack of optimized scheduling and coordination. So companies would be difficult to real-time reaction. Manufacturing Execution Systems (MES), which is for shop floor

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production management techniques and real-time information system, is the information link between the ERP and production of automatic control system (Cao and Wang 2002; Yu and Shi 2009).

Quality control is an important component part of MES. In the field of quality management, MES can effectively integrate the process level, site quality data acquisition, quality management of production processes and statistical analysis of these features which belong to the underlying control layer in tobacco enterprises (Li et al. 2007; Wang 2005; Sander 2003; Liu and Yang 2005).

Filter tips production as an important part of cigarette production process, its production efficiency and finished product quality directly affect the quality of the cigarette (MESA International 1997a). So Research of On-line Quality Management System for Filter Tips based on MES is particularly important (Maraghy and Urbanic 2003; MESA International 1997b; McClellan 1997; Kelly 1995; Object Management Group 1997; Computer System Inc 1999).

94.2 System Requirements

As an important component part of the cigarette, the quality of filter tips relates to the taste of smokers in smoking, also whether they could play a filtering tar droplet and reduce the role of nicotine intake. So quality control of the filter tips is particularly important because it is directly related to the quality of cigarettes good or bad. During the whole process, the quality control of filter tips working procedure is key point. It is a decisive role of cigarettes' qualified products.

The filter tips process in Fig. 94.1.

Currently, quality problems of filter tips are mainly concentrated in draw resistance of filter rods, hardness, circumference and length. In six production processes of filter tips, they are quantitative indicators of Tow opening, Plasticized, Rolling forming and Filter tips cutting.

So the four processes are critical detection points during the On-line Quality Management System for filter tips. Principal detection parameters is the "roll pressure, roll ratio; plasticizer supply and the quantity supplied; various parts of the filter tips temperature, diameter and glue temperature; the length of filter tips and feed frequency".

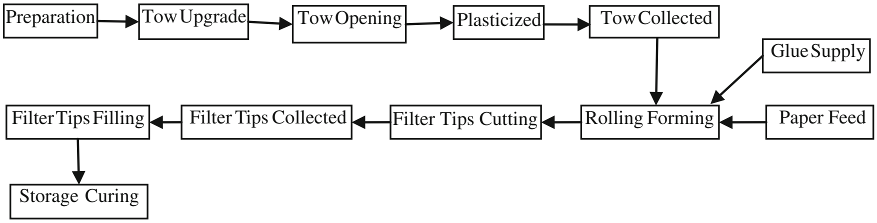


Fig. 94.1 The filter tips process

MES technology platform analyzes the real-time effective data from the filter tips manufacturing site, then it control the processing quality of each working procedure timely. To eliminate quality defects in the bud, and lower cost of quality, the platform will do real-time monitoring, prediction, diagnosis and on line debugging.

Accordingly, the following requirements, which can achieve its quality control, are:

94.2.1 Real-Time, Dynamic

At present, in most tobacco companies, quality management mostly use Static quality management and control by quality plan issued, production testing after sequence and quality of statistical reports forms. So the control effectiveness and efficiency are very restricted. On line quality management system needs to be able to collect real-time data from the manufacturing process. The system grasps the quality of the state and reflects the problem of manufacturing process. The aim is to control the production quality dynamically.

94.2.2 Visualization

Vast amounts of quality data miscellaneous and difficult to understand, and the data behind the information is also difficult to express. The system can put quality information to the tables, graphs, images and other visualization methods people are accustomed to accept by making use of information technology, they can provide the basis for quality managers.

94.2.3 Interaction

Managers in the traditional quality management system is a passive acceptance of unilateral information, it is difficult for users to interact with the management of quality data.

As a result, enterprises must meet the demand of quality management for filter tips, real-time dynamic visualization and interactivity by means of On-line Quality Management System for Filter Tips based on MES.

94.3 Visual Model of Quality Management and Control Processes

94.3.1 Information Visualization Model

The online application control, namely information visualization (IV) is applied for the filter tips quality management system based on MES. IV refers to the use of computer-supported, interactive visualization of abstract data to enhance people's awareness of the abstract information.

IV model is from the original data, data table, visual structure and view four modules. Original data maps for the data table through data transformation; and through visualization, data tables map transformation for visualization of structure, this process is the core of information visualization; finally, set up the graphics parameters through the view transformation and translate the structure to the visualization view, so the users can view the visualization of data in the database to serve a specific task from a particular point of view. Visualization of quality management to solve the main problem is the quality of the data mapping, conversion and interactive control.

94.3.2 Quality Control Processes for Filter Tips

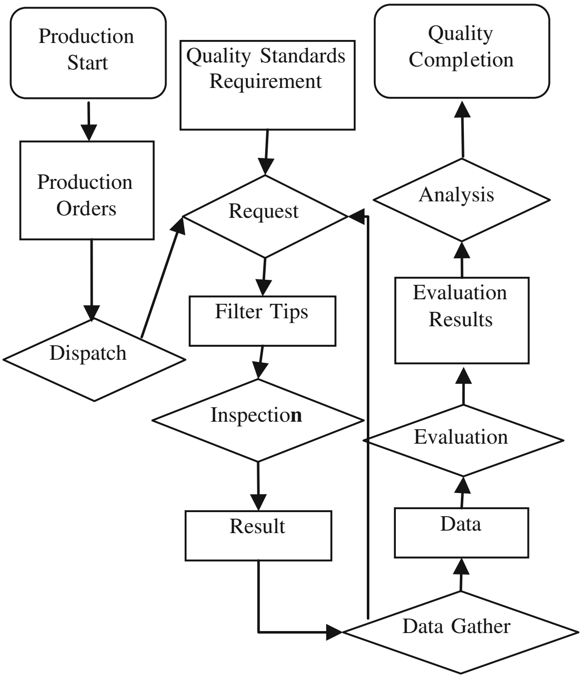
Based on production technology and processes for filter tips and combined MES, discussion on-line quality management model. It is shown in Fig. 94.2.

94.4 Functional Model of On-Line Quality Management System for Filter Tips

Based on the above analysis of the visualization of information model, and combined quality management process for filter tips, the functional model of the system is presented. It is shown in Fig. 94.3.

PDCA continuous quality improvement model used in the process of quality management, and it is a basic way to operate quality assurance system. Quality standards is the object of quality improvement, and it provides the standard to the entire quality management process; quality control is part implementation quality management, quality inspection is to check the quality control results; quality analysis is based on processing test, quality standards improvements. Four parts cycle, the product quality improve constantly.

Fig. 94.2 Quality management model



94.4.1 The Applications of Quality Control Function Module

Quality control includes two aspects. They are manufacturing process control and auxiliary process control. Physical indicators in manufacturing process quality control is to collect data automatically, then draw the control chart as well as appearance of the index through manual inspection, and inspection data entries system automatically which is collected from the bottom of shop floor. When the exception occurs, the system automatically will alarm.

In auxiliary process quality control, its job is mainly to assess the implementation of process, to monitoring equipment industry parameters, production and operating environment, to confirm the raw materials. And checking the measuring devices. When the device process parameters overrun, it will be proposed to modify the corresponding process parameters. If an exception occurs, the alarm activated alarm immediately. The same is also true for the monitoring of production operations environment. When needed for the production of raw materials and components to confirm, once an exception occurs, you will be prompted to make a re-examination request, in order to avoid quality problems in raw materials for production. Quality control function module is not a single module, when these quality control links are not processed, the system will promptly notify the relevant modules to deal effectively with, it aims to assure the quality of production furthest.

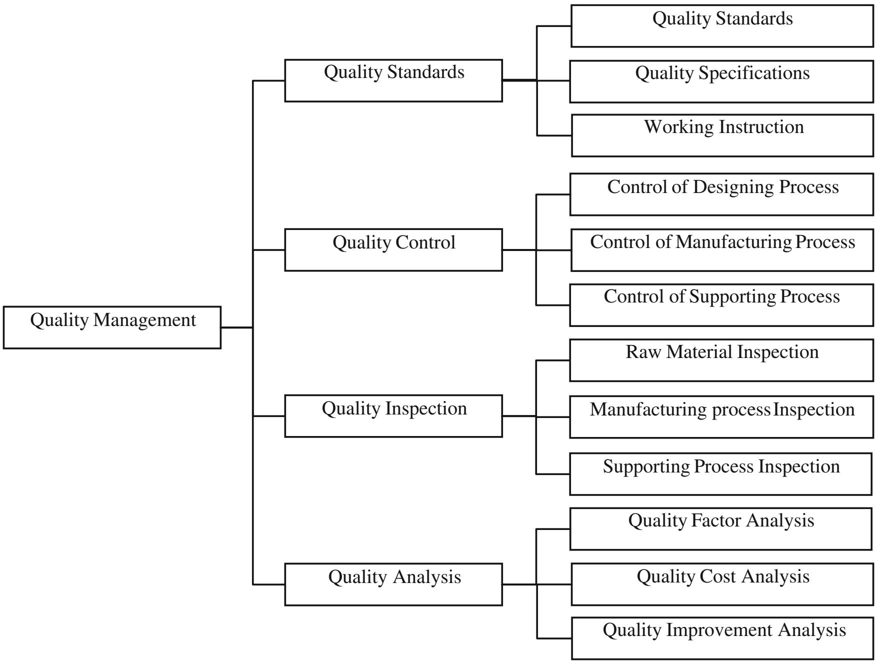


Fig. 94.3 Functional model of on-line quality management system for filter tips

94.4.2 Quality Inspection Function Module

In the MES environment, the inspection process is the focus of the quality inspection, and it does inspection of the manufacturing process, quality management point of inspection, sampling the production process, and non conforming product processing inspection.

As a data collection point, inspection of the quality management point is to select the key points in the production process, to compare the collected information and operating specifications, and to make the appropriate judgment. At the same time, in the production process of each stage of sampling, and sampling results into the system, at any time call access, quality inspection situation aggregates into quality reports. When quality inspection finds substandard products, it focus on putting information into the system timely, and determine the level, then it issues a re-examination request again.

94.4.3 Quality Analysis Module Applications

In this module, the focus is on the quality factor analysis, including product quality analysis and process conditions.

Index related will be collected to analyze the quality of products, then by mathematical statistics, analysis, it finds problems, and according to the problems to feedback and make improvements timely. To analyze the state of the product process, we should pay attention to the process status information, a comprehensive analysis of the observed information and continuous improvement can assure the product quality in the greatest degree.

94.5 Key Technologies of the System

(1) Using model-driven technology to achieve the production control based on the production model can, providing a flexible modeling tool and managing the entire production process by the model driven.
(2) Through the model-driven technology, strengthen quality control; automatically generated quality inspection request according to the changes in work orders, schedules and grades, Testing equipment data and formation the quality of data analysis and evaluation by KPI Data feedback and automatic acquisition.
(3) Realize the monitoring of the production of dynamic data, and visual display the actual situation of filter rod production process by monitoring the screen.
(4) Use the digital measuring devices, connected to the wireless transmitter to send the digital signal, and connected to a computer to transmit data through the intranet on a regular spread to the enterprise server to complete the data collected from the production site.
(5) Use the real-time database technology, realize the mass data storage and application of real-time data; acquisition multiple quality control points in the production process to achieve the production of dynamic real time data acquisition, monitoring and statistical analysis, made the production management more scientific, organization more flexible and more timely decision-making.

94.6 Conclusion

The quality management of corporation is a very complicated and important work. Quality management level has a direct impact on the survival and development. Quality management system is for continuous improvement and meeting the daily production and business needs, which can greatly enhance the competitiveness of enterprises. The key to the implementation of MES filter tips on-line quality management system is to achieve effective integration of information sharing with other MES module and the underlying control, real-time quality monitoring by the flow of information integration and control integration, the entire process of production, in order to achieve closed-loop quality control. Analysis of MES and filter tips online quality management system processes, functional model and key technologies, explore and practice on these issues, I believe that the quality management system based on MES is fine, because the homogenization and standardization of information technology is the best solution.

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Chapter 95
A Research on the Capacity Development of Chinese Construction Project Manager Based on Theory of Competency Model

Peng Huang

Abstract The particularity of construction project determines the core position of the project manager. Therefore, the development of construction project manager plays an important role in increasing enterprise's competitive ability. Studies show development of Chinese construction project manager is guaranteed by their capacity and leadership. This article, from the perspective of competency model, focuses on the content, way and effectiveness of Chinese construction project manager, concluding that the development of project manager is related with attentive selection, while development of capacity can be acquired through business training or learning.

Keywords Construction project · Project manager · Competency model · Capacity development

95.1 Introduction

At present, most of the construction enterprises are taking a project management model, that is, a project manager responsibility system. For this management model, project is the most basic construction unit, most direct economic source of revenue, and biggest place that resources are invested into.

Improving management is one of the most important work of the project department. Project has its unique particularity; most of projects are one-time, periodical and complex (Shi 2005). The ability of project manager directly determines the success of a particular project. Therefore, improving the ability and management of project manager can most benefit enterprise's competitive competence.

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To develop the capacity of the construction project manager, three key problems must be solved. First, the capacity content of the project manager must be considered; next, the development way must be determined; the last, how to evaluate the development effect must be made clear. At the same time, the theory of competency model has provided a new angle of view for further analyzing the content, method and effectiveness evaluation to the Chinese project managers (McClelland 1973).

95.2 Method and Scope of Research

Since the competency model theory was put forward, it had been widely applied; the relative study was also abundant which laid the foundation of this article. It adopts the method of literature to study the capacity development of Chinese construction project manager, further analyzing the importance of ability and plasticity, the way and methods of project development.

For the research object, this paper concentrates on construction enterprise, taking project manager as research object, while not involving IT and other industry project manager.

95.3 Competency Model of Construction Project Manager

Study of competency model was proposed by McClelland in the late 1960s (Zhong and Shi 2007) since then, the research and application of competence theory grow rapidly. At present, the competency model has already become a powerful tool of human resources development, and provided a successful model for a specific organization, job or role (Li et al. 2008). A classic of competence theory model such as “iceberg model” and “onion model” is the foundation of constructing an enterprise and a post. Nowadays, a more influential competency model is “iceberg model” put forward by Spencer and Spencer. According to “iceberg model”, competence model can be divided into knowledge, skill, concept of self, characteristic and motivation, among which knowledge means the paradigm and experience information possessed by the individual in a particular area; Skill refers to structured knowledge used to accomplish a specific task; The concept of self refers to the individual’s attitude, value or self image; characteristic refers to the individual’s physiological characteristic and the response of consistency to situation; Motivation refers to individual’s inherent power of behavior (Borman 2008). By contrast, knowledge and skill are visible and relatively explicit characteristics which are easy to change; while the concept of self, characteristic and motivation are more subtle characters, they are deep and central part which are not easy to change and can predict individual’s long-term performance. “Iceberg model” is shown in Fig. 95.1.

Competency model provides a new way for the selection, training and development of construction project which has also attracted widespread attention. Boston university enterprise education center (BUCEC) and Fox consulting company jointly develop a project manager of competence model (called BUCEC model) (Yang et al. 2008a). The model divides project manager into five types of technical skill, personal ability, capacity and leadership. Technical skill includes management of integration, scope, time, cost, quality, human resources, communication, risk and procurement; capacity and leadership include comprehensive attention, a sharp business mind and organization to create a good working environment; Individual characteristic mainly includes achievement and action, ability of good communication, influence and management so on.

"Project Management Competency Development Framework" (PMCD) is sponsored by Project Management Institute of America and has been widely applied in countries all over the world. PMCD focuses on knowledge (Alldredge and Nilan 2000), skills and behavior characteristic needed by successful project manager which is shown in Fig. 95.2. Knowledge competency consists of nine knowledge area elements; Performance competency consists of 9 elements; Personal competency consists of 6 elements.

In China, Jin Zhang established competence model of enterprise project management from three dimensional structures, namely management skills, interpersonal relationship and personal qualities. Guozheng Chen put forward dimensions of knowledge and skill, attitude, values, competency model of project manager which is composed by leadership traits. Huiling Xu put the idea that competency model of international construction project is composed by four dimensions and 22 competence model structures, the four dimensions are personal characteristics, management skills, interpersonal relationship and basic knowledge (Briscope and Hall 1999).

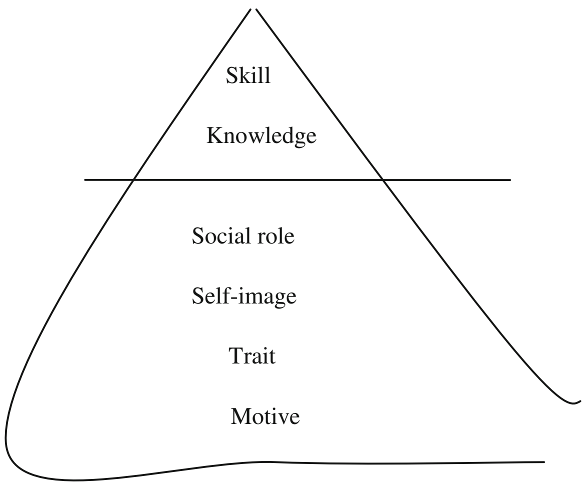

Fig. 95.1 Iceberg model (Yang et al. 2008b) (*Source* Spencer and Spencer 1993)

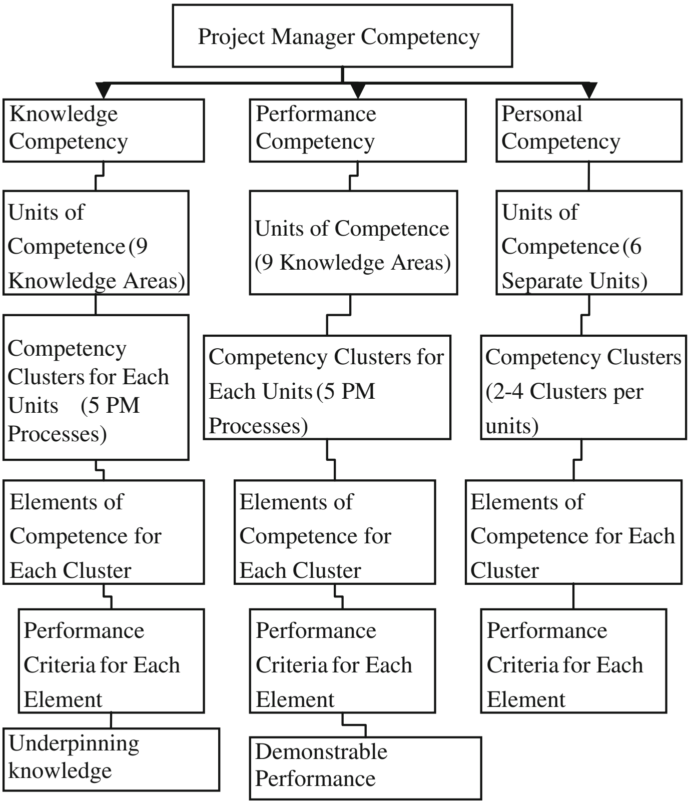

Fig. 95.2 PMCD framework (Shippmann et al. 2000) (*Source* 2002 Project Management Institute, Four Campus Boulevard, Newtown Square, PA 19073-3299 USA)

From relative research of project manager, competence of project manager mainly includes general knowledge and skills, personal and leadership traits, and interpersonal relationship which can be summarized and shown in Table 95.1.

This article mainly aims at the capacity development of project manager, so specific project manager competence is no longer involved in this paper.

95.4 Evaluation and Way of Capacity Development

Competency model guides the way of capacity development. Therefore, in point of application of the model, specific project is required to make evaluation concerning its significance and plasticity, because organization's resources are limited, especially for enterprises, they pursue the maximization of profit and the best input–output ratio (Rajadhyaksha 2005). While plasticity evaluation compensates

Table 95.1 Competence model of project manager

No	Project manager of competence category	Characteristics competence of construction project manager
1	Knowledge and skills	Management knowledge
		Technical knowledge
		Communication ability
		Ability of organization and coordination
		Ability of judging and making decisions
		Time management
		Risk identification and control ability
		Ability of controlling cost and budget
		Ability of management in conflict
		Ability of Planning target management
2	Interpersonal relationship	Leadership motivation
		Establish relationships
		Team establishment
		Authorization
		Influencial ability
3	Personal and leadership traits	Vision
		Initiative
		Responsibility
		Integrity
		Achievement orientation
		Confidence
		Innovation spirit
		Consciousness of quality
		Consciousnessof serving customers
		Personnel training

Source According to relevant research and conference

the disadvantages depending on some competency training and development project is difficult to improve.

Usually, for competence with high plasticity and great significance, we are supposed to choose the best human resources and execute compulsive training, helping them develop rapidly. For competence with low plasticity and great significance, we should take it as the focus of investigation, do not employ or promote those who can not meet the requirements of a particular post. For competence with high plasticity and low significance, we can provide them with in-house training by volunteer instructor. For competence with low plasticity and low significance, it is suggested to give priority to self-study. Therefore, different ways of developing competence can be executed in view of significance and plasticity of different competence (Hair et al. 1995). Significance of competence and matrix of plasticity evaluation and its corresponding way of development are shown in Fig. 95.3.

According to the above theory and methodology, Table 95.2 analyzes the corresponding development way and evaluates its plasticity and significance of

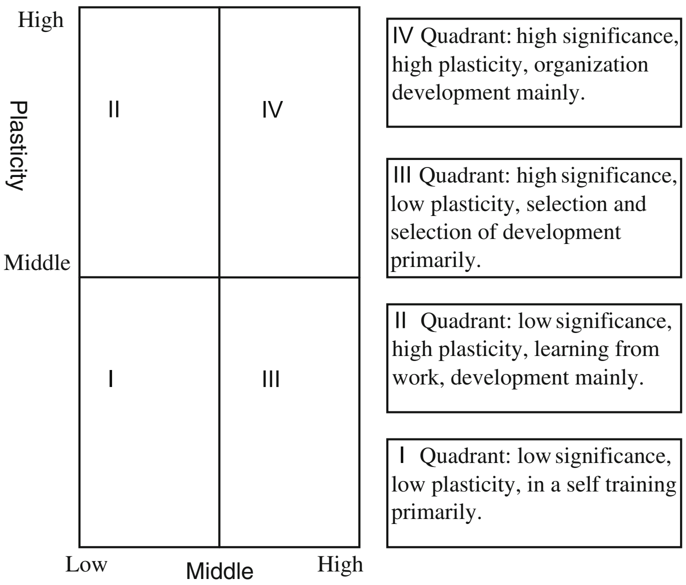

Fig. 95.3 Significance of competence and matrix of plasticity evaluation and its corresponding way of development (Kline 1998)

competence characteristics for Chinese project manager listed in Table 95.1 and is shown in Table 95.2.

According to the above analysis, the personal and leadership traits of project manager mostly belong to the third quadrant, which is hard to depend on acquired cultivation; knowledge and skills of competence belong to the second and fourth quadrant which can be acquired and improved through development. Interpersonal skills of competence also belong to the fourth quadrant which should take the organization development primarily.

Management knowledge and technical skills factors belong to the second quadrant and can be developed by training and schooling. Time management skill, risk identification and control ability, ability of controlling cost and budget and ability of management in conflict belong to the second quadrant and can be developed by work-based learning. Now, workplace learning is not a unitary concept. Holliday thinks that workplace learning is learning processes and outcomes in the way the staff to individuals or groups in particular in the workplace. This learning process and outcomes related to member of emotion and the value change, understanding of knowledge, as well as with the specific job related skills. (Holliday 1998)

Factors belonging to the third quadrant are influential ability, vision, initiative, responsibility, integrity, achievement orientation, confidence, innovation spirit, etc. These factors are often congenital form, or have formed in the early period (Loo 2000). In general, these factors are stable, and not easy to change. So, how to select these factors becomes very critical. Chinese construction enterprises should establish selection mechanism to select these factors that project manager should

Table 95.2 Evaluation model of significance and plasticity of competence for project manager

No	Characteristics competence of construction project manager	Evaluation of significance and plasticity	Way of development
1	Management knowledge	II quadrant	Learning and developing in working
	Technical knowledge	II quadrant	
	Communication ability	IV quadrant	Organization development
	Ability of organization and coordination	IV quadrant	
	Ability to make judgment and decision	IV quadrant	
	Time management	II quadrant	Learning and developing in working
	Risk identification and control ability	II quadrant	
	Ability of control cost and budget	II quadrant	
	Ability of management in conflict	II quadrant	
	Ability of planning target management	IV quadrant	Organization development
2	Leadership motivation	IV quadrant	
	Established relationships	IV quadrant	
	Team construction	IV quadrant	
	Authorization	II quadrant	
	Influential ability	III quadrant	Selection and development
3	Vision	III quadrant	
	Initiative	III quadrant	
	Responsibility	III quadrant	
	Integrity	III quadrant	
	Achievement orientation	III quadrant	
	Confidence	III quadrant	
	Innovation spirit	III quadrant	
	Quality consciousness	IV quadrant	Organization development
	Consciousness of serving customers	IV quadrant	
	Personnel training	IV quadrant	

have. Chinese construction enterprises can set up corresponding quality evaluation method to the selection of these features by combining the external advisory body.

The factors belonging to the fourth quadrant are communication ability, ability of organization and coordination, ability to make judgment and decision, ability of planning target management, leadership motivation, established relationships and team construction, etc. These factors can be developed by enterprises. Chinese construction enterprises should take corresponding development way and method to develop project manager's ability according to their characteristics.

95.5 Conclusion

This paper studies the capacity and competence of Chinese project manager according to recent research, dividing it into three aspects, that is, knowledge and skills, interpersonal relationship, personal and leadership traits. Besides, it evaluates the competence of Chinese project manager on basis of plasticity evaluation matrix.

The results show that the personal and leadership traits of project manager mostly belong to the third quadrant, which is hard to depend on acquired cultivation; knowledge and skills of competence belong to the second and fourth quadrant which can be acquired and improved through development; Interpersonal skills of competence also belong to the fourth quadrant.

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Chapter 96
A Comparative Study of Supplier Selection Based on Support Vector Machine and RBF Neural Networks

Zao-jie Kong and Jun-bin Xue

Abstract Supplier selection is one of the important parts of supply chain management. In recent years a large number of scholars have studied in this field. A large number of literatures have shown the superiority of the neural network method. Based on this, in this article, the strong classification ability of Radial Basis Function (RBF) neural network and Machine learning techniques which based on classification—Support Vector Machines (SVM) is applied in selecting the ideal supplier and comparing the results. Empirical evidence shows that SVM is more accurate than RBF neural network algorithm in the calculation of supplier selection.

Keywords Radial basis function · Supply chain management · Supplier selection · Support vector machine

Supply Chain Management (SCM) is a mode of operation which is new, advanced and could improve the business competitiveness. How to choose the right partner is a pressing and important issue, which determines a company's interests and future. The criteria of the selection of partners is according to their actual business situations, establishing the corresponding index system to predict the business rate and selecting higher score business enterprises as suppliers which are equivalent in function. Generally speaking, there are two main factors which impact the composite score of predict suppliers, the first is comprehensive index system; the second is the choice of calculation method. In recent years, artificial intelligence method has made a lot of meaningful results in predicting the actual ability of suppliers.

Although Neural Networks (Artificial Neural Network, ANN) and Support Vector Machine (SVM) have some similarities in the structure, their optimization algorithm exists essential difference. Neural network is based on empirical risk

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minimization principle, prone to over-fitting and easy to fall into local minima. Support Vector Machine is based on the principle of a structure risk minimization, which makes SVM have good generalization ability, this algorithm is a convex optimization problem, therefore, the local optimal solution is global optimal solution. The results show that the outcome of Support Vector Machine method with different kernel function can be similar. This shows that the choice of Support Vector Machine model has a certain insensitivity, and the selecting of neural network structure tend to having greater impact on its properties (Wu and Sun 2006; Zhang et al. 2004; He 2006).

Radial Basis Function (RBF) neural network most commonly used radial basis function is the Gaussian radial basis function, Support Vector Machines most commonly used kernel function is also Gaussian radial basis function. And this article raises the index system of supplier selection on the supply chain environment and chooses the Gaussian radial basis function, Support Vector Machine and Gaussian radial basis function neural network to simulate and compare the selection of supplier.

96.1 The Description of Radial Basis Neural Network and Support Vector Machine Algorithm

96.1.1 RBF Neural Network

The most basic RBF neural network includes three layers: input layer, hidden layer and output layer. Each layer has a completely different function: The function of the input layer is to connect the network with the external environment; the function of the hidden layer is to carry out linear transformation from input space to hidden space with a higher dimension usually. Output layer is linear, whose function is to provide response for output layer's activation signal. Figure 96.1 describes an three layers RBF neural network structure with input nodes, hidden layer nodes and output nodes (He 2006).

Among them, $x = [x_1, x_2 \ldots x_n]^T$ is an input vector; $\Phi = [\varphi(x, c_1), \varphi(x, c_2), \ldots \varphi(x, c_k)]$ is an network hidden layer output matrix, and c_i stands for the hidden

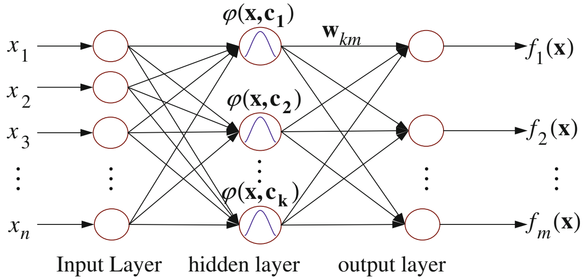

Fig. 96.1 RBF neural network structure

layer node location of i, $i = 1, 2, \ldots, k$; $W_{km} = [w_1, w_2, \ldots, w_k]^T$ are network output weight matrix, among them, $W_i = [w_{i1}, w_{i2}, \ldots, w_{im}]^T$; $F(x) = [f_1(x), f_2(x), \ldots, f_m(x)]^T$ are network output vectors.

Activation function of hidden layer is the radial basis function. It usually meets Micchelli's Theorem, there are three radial basis functions play an important role in RBF neural network:

(l) Multiquadrics function

$$\phi(\mathrm{x}, \mathrm{c}_i) = \left(\mathrm{x}^2 + \mathrm{c}_i^2\right)^{1/2}, \quad i = 1, 2, \ldots, k$$

(2) Inverse multiquadrics function

$$\phi(\mathrm{x}, \mathrm{c}_i) = \frac{1}{\left(x^2 + c_i^2\right)^{1/2}}, \quad i = 1, 2, \ldots, k$$

(3) Guass function

$$\phi(x, c_i) = \exp\left(-\frac{\|x - c_i\|^2}{2\sigma^2}\right), \; i = 1, 2, \ldots, k$$

among it, σ *is the center width of the hidden layer*.

This article take Guass function as the hidden layer activation function of the RBF neural network, because Guass function has the following advantages:

(1) Representation is simple; it will not increase too much complexity even for multi-variable input;
(2) Wonderful smoothness, derivative of any order can exist;
(3) Good analytical, so it is convenient for theoretical analysis.

96.1.2 Support Vector Machine

Support Vector Machine (SVM) is a new kind of learning machine, it was first proposed by Vapnik (Vapnik 1995). It is based on the principle of Structural Risk Minimization (SRM), different from ordinary calculation theory. In recent years, the Support Vector Machine (SVM) is successfully applied in many fields, such as the biometrics, text classification, fault detection, image detection, forecasting of power system and time series etc. The input space that these applications involves is a high dimensional space, its successful applications indicate that SVM algorithm has overcome the dimension disaster of feature space (Hu and Zhang 2007; Zhang et al. 2004).

The form of SVM classification function is similar to a neural network; it can output a linear combination of the node. Each intermediate node corresponds to a support vector (Wu and Sun 2006), as shown in Fig. 96.2: Were recorded $x \subseteq R^n$ and Y as input and output space, $S = ((x_1, y_1), (x_2, y_2), \ldots (x_l, y_l)) \subseteq (X \times Y)^l$

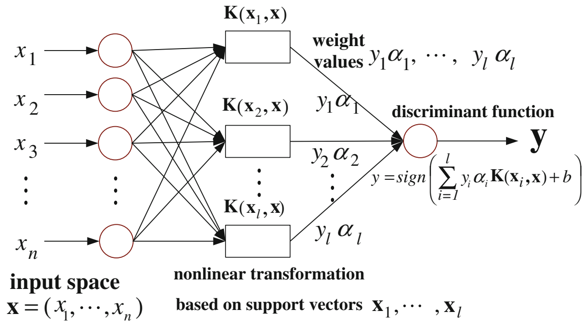

Fig. 96.2 Support vector machine structure

is training group. l is the size of it. The nature of the output Y is to decide the type of the learning (Cristianini and Shawe-Taylor 2005).

$Y = \{+1, -1\}$ stands for two classification problems. $Y = \{1, 2, 3, \ldots m\}$ stands for Multi-classification problems. $Y \subseteq R^n$ stands for Regression problems.

Support Vector Machine is the type of the maximum margin classifier, Classification problem can be said for the optimization problem, the formula is:

$$\min \quad \Phi(w) = \frac{1}{2}\|w\|^2 \tag{96.1}$$

$$s.t. \quad \mathrm{y}_i(\mathrm{x}_i \cdot \mathrm{w} + \mathrm{b}) \geq 1, \quad i = 1, 2, \ldots, 1 \tag{96.2}$$

Vapnik shows that pattern recognition and regression problems of learning support vector machine training with the boundary constraints is essentially solving Linear equality constraints and Quadratic optimization problem (Vapnik 1995). support vector machine are applied in the aspects of regression, It mainly concludes ε-Support Vector Regression (ε-SVR) that was proposed by Vapnik and υ-Support Vector Regression (υ-SVR) that was proposed by Scholkopf, etc. ε-SVR controls high precision of the algorithm roughly by determining ε beforehand, in some cases, it may hope that it is better to get the higher precision, not the one that already have been given, υ-SVR algorithm can automatically make ε reach minimization in order to make sure the algorithm has the highest precision.

Standard forms of the ε-SVR is:

$$\min_{\omega, b, \xi, \xi^*} \frac{1}{2} w^T w + C \sum_{i=1}^{l} \xi_i + C \sum_{i=1}^{l} \xi_i^* \tag{96.3}$$

$$s.t. \begin{cases} w^T \phi(x_i) + b - y_i \leq \varepsilon + \xi \\ y_i - w^T \phi(x_i) - b \leq \varepsilon + \xi_i^* \\ \xi_i, \xi_i^* \geq 0 \\ i = 1, \ldots l \end{cases} \tag{96.4}$$

Among them, $W \in R^n$, $b \in R$ and ξ_i, ξ^* are Relaxation variables, C is the specified constant, it takes action between improving the generalization ability and reducing the error, ε is a positive number that needs to set in advance, it is mainly used to control the precision of algorithm.

The dual problem is:

$$\min_{\alpha,\alpha^*} \frac{1}{2}(\alpha - \alpha^*)^{\mathrm{T}} \mathrm{Q}(\alpha - \alpha^*) + \varepsilon \sum_{i=1}^{l} \left(\alpha_i + \alpha_i^*\right) + \sum_{i=1}^{l} z_i \left(\alpha_i - \alpha_i^*\right) \tag{96.5}$$

$$s.t. \sum_{i=1}^{l} \left(\alpha_i - \alpha_i^*\right) = 0, 0 \leq \alpha_i, \alpha_i^* \leq C, i = 1, \ldots, l. \tag{96.6}$$

Here, $Q_{ij} = K\left(x_i, x_j\right) = \phi(x_i)^T \phi\left(x_j\right)$ α_i, α_i^* are the parameters of this dual problem, $K(x, x_i)$ is the kernel function, up to now, the most commonly research and used kernel functions are:

Linear kernel function:

$$K(x, x_i) = x_i \cdot x;$$

Polynomial kernel function:

$$K(x_i, x) = [(x \cdot x_i) + 1]^q;$$

Gaussian kernel function:

$$K(x_i, x) = \exp\left[-\frac{\|x - x_i\|^2}{2\sigma^2}\right];$$

Sigmoid kernel function:

$$K(x_i, x) = \tanh(v(x \cdot x_i) + c);$$

And the *discriminated function is*:

$$y = \sum_{i=1}^{l} \left(-\alpha_i + \alpha_i^*\right) K(x_i, x) + b.$$

96.2 Suppliers Index and Calculation

In this article, Index system includes three-level indicators (product information, enterprise information, delivery and services) and 20 secondary targets, shown in Fig. 96.3.

In this article, the development platform is MATLAB, and simulated data in Table 96.1, the higher of the output value, indicates the higher evaluation of the

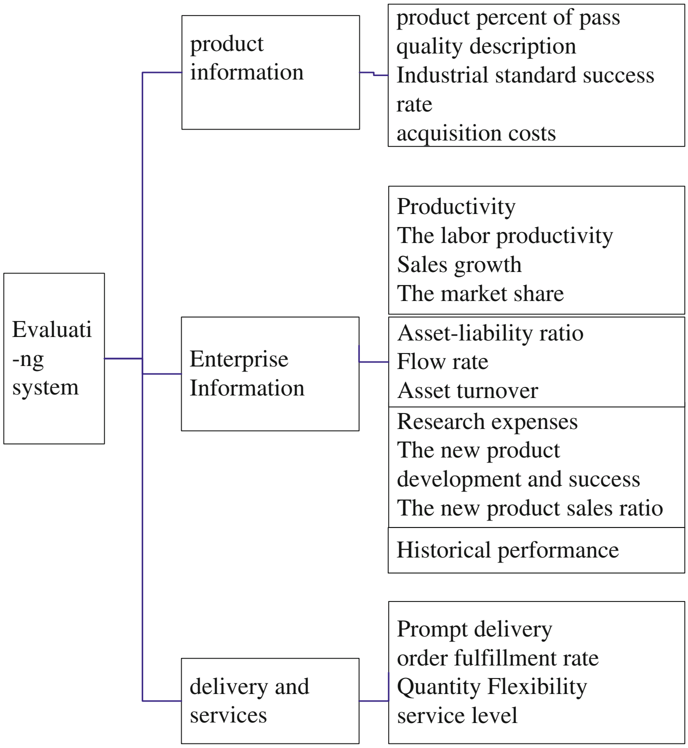

Fig. 96.3 Supplier evaluation index

enterprise. This article selects former 36 samples as training samples and later 4 samples as test data (Cong 2003; Wen 2000).

According to the training sample, obtaining an average of samples $\bar{X} = \frac{1}{n}\sum_{i=1}^{n} x_i$, and regard it as the sample center, then we can get the minimum distance 1.481, maximum distance 23.91, the average distance 9.9999 to the samples center. Parameters of Gaussian function range from 0.1 to 10.5, the interval is 0.1, Support vector's penalty function $C = 1600$, using support vector machine and radial basis neural network simulate the value of 105 σ which have described in this article. Comparing the mean square error Mean Square Error (MSE) between them, the result is that there are 61 $MSE(svm)$ of support vector machines that are less than $MSE(rbf)$ radial basis neural network. The maximum difference 0.003993 and the minimum difference $1.9E-0.5$ of the remaining. When $\sigma = 0.4$, $MSE(rbf) = 0.02483$; when $\sigma = 0.41$, $MSE(svm) = 0.024795$. It is easy to see that support vector machine is superior than Neural network in the prediction accuracy of supplier evaluation. Part of the test result data in Table 96.2, data sources see reference.

Table 96.1 Data of supplier samples

	PQR	QCC	ISCR	LP	AR	PA	RC	AC	CR	TF	QF	NPS	ATD	OCR	AT	SG	MOR	SPD	SL	HP	EV
1	0.8	0.6	0.8	0.8	0.8	0.6	0.8	150	0.5	0.63	0.2	0.4	0.9	0.5	0.8	0.65	0.65	0.8	4	4	0.8
2	0.8	0.8	0.8	0.99	0.8	0.8	0.6	150	0.5	0.63	0.2	0.4	0.9	0.5	0.8	0.65	0.65	0.8	4	4	0.88
3	0.8	0.8	0.8	0.99	0.8	0.8	0.8	150	0.5	0.38	0.1	0.2	0.9	0.5	0.8	0.65	0.65	0.8	4	4	0.95
4	0.8	0.6	0.8	0.8	0.8	0.6	0.8	145	0.5	0.63	0.2	0.4	0.9	0.5	0.6	0.65	0.65	0.8	4	5	0.85
5	0.99	0.99	0.99	0.99	0.99	0.8	0.99	130	0.6	0.8	0.8	0.78	0.99	0.99	0.99	0.85	0.8	0.99	5	5	1
6	0.6	0.6	0.4	0.4	0.6	0.4	0.6	130	0.33	0.13	0.03	0.1	0.99	0.25	0.7	0.85	0.7	0.99	5	5	0.4
7	0.99	0.99	0.99	0.99	0.99	0.99	0.99	130	0.5	0.7	0.7	0.75	0.99	0.98	0.8	0.85	0.75	0.99	5	5	1
8	0.99	0.99	0.99	0.99	0.99	0.6	0.4	130	0.33	0.13	0.03	0.1	0.99	0.25	0.4	0.85	0.7	0.2	2	1	0.7
9	0.99	0.99	0.99	0.99	0.99	0.8	0.2	130	0.33	0.13	0.03	0.1	0.7	0.58	0.6	0.85	0.7	0.99	4	3	0.75
10	0.6	0.6	0.99	0.99	0.99	0.8	0.4	130	0.33	0.13	0.03	0.1	0.99	0.25	0.4	0.85	0.7	0.99	3	5	0.8
11	0.99	0.99	0.99	0.99	0.99	0.8	0.6	150	0.33	0.13	0.03	0.1	0.99	0.25	0.8	0.85	0.7	0.99	4	5	0.95
12	0.99	0.99	0.99	0.99	0.99	0.4	0.6	165	0.33	0.13	0.03	0.1	0.99	0.25	0.6	0.85	0.7	0.99	4	5	0.12
13	0.99	0.99	0.99	0.99	0.99	0.6	0.8	160	0.33	0.13	0.03	0.1	0.99	0.25	0.4	0.85	0.7	0.99	5	5	0.52
14	0.99	0.99	0.99	0.99	0.99	0.8	0.4	130	0.99	0.13	0.03	0.1	0.99	0.25	0.4	0.85	0.7	0.99	3	4	0.7
15	0.99	0.99	0.99	0.99	0.99	0.99	0.6	130	0.33	0.63	0.03	0.1	0.99	0.25	0.6	0.85	0.7	0.99	4	5	0.66
16	0.99	0.99	0.99	0.99	0.99	0.4	0.4	130	0.33	0.38	0.03	0.1	0.99	0.58	0.8	0.85	0.7	0.99	4	5	0.76
17	0.4	0.4	0.4	0.4	0.4	0.2	0.2	170	0.83	0.99	0.99	0.99	0.6	0.99	0.4	0.95	0.95	0.2	3	1	0.05
18	0.4	0.4	0.4	0.4	0.4	0.6	0.8	135	0.83	0.99	0.99	0.99	0.6	0.99	0.2	0.1	0.08	0.2	2	1	0.05
19	0.4	0.4	0.4	0.4	0.4	0.4	0.6	135	0.5	0.99	0.03	0.1	0.99	0.25	0.6	0.9	0.85	0.8	3	3	0.05
20	0.8	0.8	0.6	0.8	0.8	0.6	0.6	155	0.5	0.5	0.1	0.4	0.99	0.5	0.8	0.7	0.8	0.8	4	4	0.75
21	0.8	0.8	0.8	0.99	0.8	0.8	0.8	155	0.5	0.5	0.1	0.4	0.99	0.5	0.99	0.7	0.8	0.8	5	4	0.8
22	0.8	0.8	0.8	0.8	0.8	0.4	0.8	153	0.5	0.25	0.1	0.4	0.99	0.5	0.99	0.7	0.8	0.8	5	4	0.85
23	0.8	0.8	0.6	0.8	0.8	0.6	0.99	155	0.33	0.25	0.03	0.04	0.99	0.5	0.99	0.7	0.8	0.8	5	5	0.92
24	0.8	0.8	0.99	0.8	0.8	0.8	0.6	160	0.33	0.25	0.03	0.04	0.99	0.5	0.6	0.7	0.8	0.99	5	5	0.85
25	0.8	0.8	0.8	0.99	0.99	0.4	0.4	145	0.5	0.63	0.1	0.2	0.9	0.5	0.8	0.7	0.8	0.8	4	4	0.9
26	0.8	0.6	0.8	0.99	0.8	0.2	0.6	150	0.5	0.63	0.03	0.04	0.9	0.5	0.6	0.65	0.65	0.8	4	4	0.89
27	0.99	0.99	0.99	0.99	0.4	0.6	0.8	145	0.5	0.25	0.5	0.99	0.7	0.33	0.4	0.1	0.1	0.2	2	1	0.52
28	0.99	0.99	0.99	0.99	0.4	0.8	0.2	155	0.5	0.25	0.5	0.99	0.7	0.33	0.4	0.12	0.07	0.4	1	2	0.38
29	0.99	0.99	0.99	0.99	0.4	0.4	0.4	155	0.5	0.63	0.25	0.99	0.7	0.33	0.2	0.12	0.07	0.4	2	2	0.48

(continued)

Table 96.1 (continued)

	PQR	QCC	ISCR	LP	AR	PA	RC	AC	CR	TF	QF	NPS	ATD	OCR	AT	SG	MOR	SPD	SL	HP	EV
30	0.99	0.99	0.99	0.99	0.6	0.8	0.2	152	0.5	0.25	0.5	0.99	0.9	0.33	0.6	0.52	0.67	0.6	3	3	0.85
31	0.8	0.8	0.8	0.99	0.8	0.6	0.8	155	0.5	0.25	0.05	0.4	0.99	0.5	0.8	0.7	0.8	0.8	4	4	0.88
32	0.8	0.8	0.8	0.8	0.8	0.8	0.8	153	0.5	0.25	0.1	0.4	0.99	0.25	0.8	0.7	0.8	0.8	4	4	0.91
33	0.8	0.8	0.8	0.98	0.8	0.4	0.99	155	0.33	0.25	0.03	0.04	0.99	0.5	0.99	0.7	0.8	0.8	5	5	0.96
34	0.8	0.8	0.99	0.8	0.8	0.2	0.6	150	0.33	0.25	0.03	0.04	0.99	0.5	0.6	0.7	0.8	0.99	4	5	0.97
35	0.8	0.8	0.8	0.8	0.99	0.6	0.8	145	0.5	0.63	0.1	0.2	0.9	0.5	0.4	0.7	0.8	0.6	3	3	0.82
36	0.8	0.6	0.8	0.8	0.8	0.8	0.6	150	0.5	0.63	0.03	0.04	0.9	0.5	0.2	0.65	0.65	0.6	2	1	0.84
37	0.99	0.99	0.99	0.99	0.4	0.6	0.4	145	0.5	0.25	0.05	0.99	0.7	0.33	0.6	0.1	0.1	0.2	1	3	0.72
38	0.99	0.99	0.99	0.99	0.4	0.8	0.2	155	0.5	0.25	0.5	0.2	0.7	0.33	0.8	0.12	0.1	0.4	4	3	0.65
39	0.99	0.99	0.99	0.99	0.4	0.8	0.4	150	0.5	0.63	0.25	0.99	0.7	0.33	0.4	0.12	0.1	0.4	2	2	0.68
40	0.99	0.99	0.8	0.98	0.6	0.8	0.6	152	0.5	0.25	0.5	0.99	0.9	0.33	0.6	0.52	0.67	0.6	3	3	0.68

PQR Product qualified rate
QCC Quality certification conditions
ISCR Industry standard compliance rate
LP Labor productivity
AR Asset-liability ratio
PA Productivity advantage
RC Research costs
AC Acquisition costs
CR Current ratio
TF Time flexible
QF Quantity flexibility
NPS New product sales ratio
ATD Ability of timely delivery
OCR Order completion rate
AT Asset turnover
SG Sales growth
MOR Market occupancy rate
SPD The success rate of new product development
SL Service level
HP Historical Performance
EV Evaluation value

Table 96.2 The comparison of test samples' mean square error MSE

σ	0.1	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
MSE(svm)	0.02543	0.024902	0.029316	0.032596	0.032133	0.030025	0.027609	0.025713	0.024836	0.025171	0.02671
MSE(rbf)	0.02703	0.026365	0.033413	0.031905	0.032212	0.031558	0.045816	0.84521	0.2061	0.25765	2.5175
SVM < RBF	1	1	1	0	1	1	1	1	1	1	1
σ	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5
MSE(svm)	0.02938	0.032631	0.036399	0.04046	0.04467	0.048895	0.053045	0.05706	0.060899	0.064512	0.06795
MSE(rbf)	0.05505	0.03279	0.036023	0.039276	0.16475	0.048209	0.052339	0.055821	0.065122	0.080189	0.07102
SVM < RBF	1	1	0	0	0	0	0	0	1	1	1

96.3 Conclusion

In recent years, logistics supply chain management is a hot topic, selecting suppliers is an important and difficult work in supply chain management. From the above examples we can realize that support vector machine (SVM) method is superior than RBF neural network no matter in the training speed or training accuracy, It can effectively resolve the shortage of neural network method in the process of supplier selection, and provide an effective tool for the enterprises in selecting partners.

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Chapter 97
A Multi-Objective Fuzzy Programming Model for Coordinate Operations of a Supply Chain with Uncertain Demands

Jia-wang Xu, Yi Zhang and Li-qiang Zhao

Abstract The coordinate operating process of a supply chain is considered. The supply chain is consisting of a manufacturer, a supplier and several customers, the semi-finished products of the supplier are raw materials of the manufacturer, demands of customers are uncertain, and the uncertainties of demands are described as fuzzy sets. A multi-objective fuzzy programming model for coordinate operations of the supply chain is constructed and a numerical example is proposed. The results of the numerical example show that decision makers can obtain an optimal operations strategy by using the model proposed in this paper according to the level of uncertainties of demands, and the operation strategy possesses robustness in same ways.

Keywords Coordinate operations · Fuzzy programming · Multi-objective programming · Supply chain · Uncertainty

97.1 Introduction

In typical supply chains, their characteristics of complexities and inherent uncertainties in the operating process challenge the research of supply chain modeling, especially when we must consider these uncertainties. Even so, there are

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still many literatures, which have done some researches on operating problems under uncertain environment (Cardona-Valdés et al. 2011; Lin and Wang 2011; He and Zhao 2001; Ben-Tal et al. 2009; Yohanes et al. 2012; Trienekens and 2012; Krishnendu et al. 2012).

Recently, Chen et al. (2010) set up a fuzzy programming model of supply chain with uncertain supply and demand. In this model fuzzy sets were used to indicate the uncertainty in the supply and demand of supply chain. Cardona-Valdés et al. (2011) developed a multi-objective stochastic optimization model under demand uncertainty, where the inherent risk is modeled by scenarios. Lin and Wang (2011) studied a supply chain network design problem under supply and demand uncertainty with embedded supply chain disruption mitigation strategies, postponement with downward substitution, centralized stocking and supplier sourcing base. Bidhandi and Yusuff (2011) proposed an integrated model and a modified solution method for solving supply chain network design problems under uncertainty. The stochastic supply chain network design model was provided as a two-stage stochastic program where the two stages in the decision-making process correspond to the strategic and tactical decisions. The inputs to supply chain planning models are subject to environmental and system uncertainties. Kabak and Ülengin (2011) proposed a fuzzy set theory-based model to deal with those uncertainties, and used a possibilistic linear programming model to make strategic resource-planning decisions using fuzzy demand forecasts and fuzzy yield rate as well as other inputs such as costs and capacities.

Here, the coordinated operating process for a class of supply chain consisting of a single manufacturer, a single supplier and several customers is considered. In this supply chain, the semi-finished products of the supplier produced are raw materials of the manufacturer. Product demands of customers are uncertain, and can be denoted as fuzzy sets. In the processing of operations, the manufacturer decides how many semi-finished products make orders from the supplier at each phase. Similarly, the supplier also decides how many semi-finished products should deliver to the manufacture in order to maximum its profits. In each phase, the manufacturer's ordering quantities is equal to the supplier's delivering quantities. That is, the operating of the supply chain is coordinated, which is the top-priority objective for the supply chain operations. Moreover, the manufacturer and the supplier must decide his optimal operational strategies under respective market environments. The framework of the supply chain we considered is shown as Fig. 97.1. By describing uncertain demands as fuzzy sets, and using the

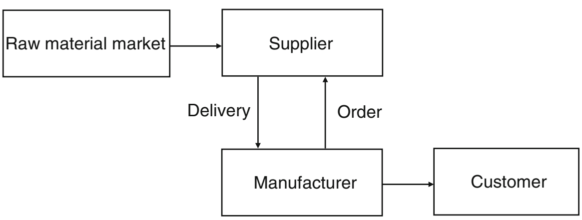

Fig. 97.1 The framework of the supply chain

approaches of fuzzy programming and multi-objective programming, we propose a multi-objective fuzzy programming model for coordinate operations of the supply chain.

97.2 Notations and Hypothese

97.2.1 Notations

Indexes:

j the index of product, $j \in \{1, \ldots, J\}$;
i the index of semi-finished product, $i \in \{1, \ldots, I\}$;
h the index of raw material, $h \in \{1, \ldots, H\}$;
t the index of phase, $t \in \{1, \ldots, T\}$.

Decision variables:

v_{jt} the quantity of product j manufacturer sales to customers at phase *t;*
z_{jt} the quantity of product j manufacturer outputs at phase *t;*
z_{jt}^L the quantity of product j manufacturer inventories at phase *t;*
y_{it}^L the quantity of semi-finished product i manufacturer inventories at phase *t;*
b_{it} the quantity of semi-finished product i manufacturer orders at phase *t;*
x_{it} the quantity of semi-finished product i supplier outputs at phase t;
l_{it} the quantity of semi-finished product i supplier delivers to manufacturer at phase *t;*
x_{it}^L the quantity of semi-finished product i supplier inventories at phase t.

Parameters:

d_{jt} the demand of customers;
p_{jt} the price of product;
q_{it} the price of semi-finished product;
r_{ht} the price of raw material;
c_j^z the variable cost of product;
c_i^x the variable cost of semi-finished product;
h_j^z the inventory cost of product;
h_i^y the manufacturer's inventory cost for semi-finished product;
h_i^x the supplier's inventory cost for semi-finished product;
$K^{\max}$ the manufacturer' maximum production capacity;
$G^{\max}$ the supplier's maximum production capacity;
α_j^k capacity consuming rate for product;
α_i^g capacity consuming rate for semi-finished product;
o_j^z occupied inventory of unit product;
o_j^y the manufacturer's occupied inventory for unit semi-finished product;

o_i^x the supplier's occupied inventory for unit semi-finished product;
$z^{L^{\max}}$ the manufacturer's total inventory level for products;
$y^{L^{\max}}$ the manufacturer's total inventory level for semi-finished products;
$x^{L^{\max}}$ the supplier's total inventory level for semi-finished products
$z_{j0}^{L'}$ the manufacturer's initial inventory for product;
$y_{j0}^{L'}$ the manufacturer's initial inventory for semi-finished product;
$x_{i0}^{L'}$ the supplier's initial inventory for semi-finished product;
s_{ij}^y the BOM coefficient of product;
s_{hi}^r the BOM coefficient of semi-finished product;
s_{ht} the quantity of raw material h the raw material market supplies at phase t.

97.2.2 Hypotheses

In the operations process of the supply chain, demands are all uncertain. Under normal circumstances, uncertainty can be described as a finite interval. For the convenience of analysis, we described uncertain demand d_{jt} as $\left[d_{jt}, d_{jt} + \Delta d_{jt}\right]$. Where, Δd_{jt} is a given nonnegative constant, it's the fluctuating quantity of demand d_{jt}, and denotes the uncertain degree of demand. Let $\Delta d_{jt} = \rho\,\% \times d_{jt}$, we can adjust the uncertain degree of demand by changing the flexibility degree ρ.

Let u_{jt} and ω_{jt} be respectively the quantity of unsatisfied demand and unit punishment of not meeting demand for product i at phase t. We consider three operational objectives in the operations process of supply chain.

(1) The operating process of the supply chain is coordinated. That is, the quantity of semi-finished product supplier delivers to manufacturer is nicely equals to the quantity manufacturer orders in each phase.
(2) The operating objective of manufacturer is pursuing profits maximization.
(3) The operating objective of supplier is also pursuing profits maximization.

97.3 The Model

97.3.1 For Manufacturer

Objective function:

The operating objective of manufacturer is pursuing profits maximization. When demands are uncertain, the objective function of the operating model for manufacturer can be expressed as following.

$$\max C^P = \sum\nolimits_t \left[\sum\nolimits_j \left(p_{jt}v_{jt} - c_j^z z_{jt} - h_j^z z_{jt}^L - \omega_{jt}u_{jt}\right) - \sum\nolimits_i \left(q_{it}b_{it} + h_i^y y_{it}^L\right)\right] \tag{97.1}$$

Constraint conditions:

$$\sum_{j=1}^{J} \alpha_j^k z_{jt} \le K^{\max}, \forall t \tag{97.2}$$

$$z_{jt}^L = z_{j,t-1}^L + z_{jt} - v_{jt} - u_{jt}, \forall j, t \tag{97.3}$$

$$z_{j0}^L = z_{j0}^{L'}, \forall j \tag{97.4}$$

$$\sum_{j=1}^{J} o_j^z z_{jt}^L \le z^{L^{\max}}, \forall t \tag{97.5}$$

$$y_{it}^L = y_{i,t-1}^L + b_{it} - \sum_{j=1}^{J} s_{ij}^y z_{jt}, \forall i, t \tag{97.6}$$

$$y_{i0}^L = y_{i0}^{L'}, \forall i \tag{97.7}$$

$$\sum_{i=1}^{I} o_i^y y_{it}^L \le y^{L^{\max}}, \forall t \tag{97.8}$$

$$v_{jt} + u_{jt} = d_{jt}, \forall j, t \tag{97.9}$$

When demand d_{jt} is uncertain ($\rho \neq 0$), in order to set up the fuzzy programming model for supply chain operations, we convert objective function (97.1) into membership function as follows.

$$\mu\left(C^P\right) = \begin{cases} 1, & C^P \le C_{\min}^P \\ \frac{C_{\max}^P - C^P}{C_{\max}^P - C_{\min}^P}, & C_{\min}^P < C^P \le C_{\max}^P \\ 0, & C^P > C_{\max}^P \end{cases} \tag{97.10}$$

where, $C_{\min}^P$ and $C_{\max}^P$ are the minimum and maximum expected profit of manufacturer respectively, and $C_{\min}^P \le C^P \le C_{\max}^P$. In practice, we can provide the specific estimate value of $C_{\min}^P$ and $C_{\max}^P$ according to the optimal solutions of corresponding mathematical programming problem under certain demands.

By converting restricted condition (97.9) into membership function, we can get the following equations.

$$\mu\left(d_{jt}\right) = \begin{cases} 1, & v_{jt} + u_{jt} \le d_{jt} \\ 1 - \frac{v_{jt} + u_{jt} - d_{jt}}{\Delta d_{jt}}, & d_{jt} < v_{jt} + u_{jt} \le d_{jt} + \Delta d_{jt} \\ 0, & v_{jt} + u_{jt} > d_{jt} + \Delta d_{jt} \end{cases} \tag{97.11}$$

The fuzzy programming model we proposed above contains membership functions. For convenience, we transform the fuzzy programming operations model of the manufacturer into a linear programming model as follows by using the principles of fuzzy mathematics.

Objective function:

$$\min \lambda \tag{97.12}$$

where, $0 \leq \lambda \leq 1$.

Constraint conditions:

$$\frac{C^P_{\max} - C^P}{C^P_{\max} - C^P_{\min}} \leq \lambda \tag{97.13}$$

$$1 - \frac{v_{jt} + u_{jt} - d_{jt}}{\Delta d_{jt}} \leq \lambda, \forall j, t \tag{97.14}$$

Other constraints are (97.2)–(97.8).

Nonnegative conditions:

$$z_{jt}, z^L_{jt}, v_{jt}, u_{jt}, b_{it}, y^L_{it} \geq 0, \forall i, j, t \tag{97.15}$$

97.3.2 For Supplier

Objective function:

$$\max C^S = \sum\nolimits_t \sum\nolimits_i \left[q_{it} l_{it} - h^x_i x^L_{it} - \left(c^x_i + \sum\nolimits_h r_{ht} s^r_{hi} \right) x_{it} \right] \tag{97.16}$$

Constraint conditions:

$$l_{it} \leq b_{it}, \forall i, t \tag{97.17}$$

$$\sum_{i=1}^{I} \alpha^g_i x_{it} \leq G^{\max}, \forall t \tag{97.18}$$

$$x^L_{it} = x^L_{i,t-1} + x_{it} - l_{it}, \forall i, t \tag{97.19}$$

$$x^L_{i0} = x^{L'}_{i0}, \forall i \tag{97.20}$$

$$\sum_{i=1}^{I} o^x_i x^L_{it} \leq x^{L^{\max}}, \forall t \tag{97.21}$$

$$\sum_{i=1}^{I} s^r_{hi} x_{it} \leq s_{ht}, \forall h, t \tag{97.22}$$

Nonnegative conditions:

$$x_{it}, x_{it}^{L}, l_{it} \geq 0, \forall i, t. \tag{97.23}$$

97.3.3 The Coordinate Operation Model for the Supply Chain Under Uncertain Demands

Objective function:

$$\min P_1 \times \sum_t \sum_i \left(d_{it}^{-} + d_{it}^{+}\right) + P_2 \times \left(d_P^{+} + d_s^{-}\right) \tag{97.24}$$

Constraint conditions:

$$-b_{it} + l_{it} + d_{it}^{-} - d_{it}^{+} = 0, \forall i, t \tag{97.25}$$

$$\lambda + d_P^{-} - d_P^{+} = 0 \tag{97.26}$$

$$C^S + d_S^{-} - d_S^{+} = M^S \tag{97.27}$$

$$C^S - \sum_t \sum_i \left[q_{it} l_{it} - h_i^x x_{it}^L - \left(c_i^x + \sum_h r_{ht} s_{hi}^r\right) x_{it}\right] \leq 0 \tag{97.28}$$

In Eq. (97.26), $0 \leq \lambda \leq 1$, so $0 \leq d_P^{-} \leq 1$ and $0 \leq d_P^{+} \leq 1$. However, we can see from Eq. (97.27), d_S^{-} and d_S^{+} may be much larger than 1. In order to ensure objective 2 and objective 3 have same priority level, we rewrite Eq. (97.26) as follows.

$$M^S * \lambda + d_P^{-} - d_P^{+} = 0 \tag{97.29}$$

Other constraint conditions of the supply chain operations under uncertain demands are listed as follows.

Conditions (97.2)–(97.8)
Conditions (97.3)–(97.14)
Conditions (97.18)–(97.22)
$0 \leq \lambda \leq 1$

Nonnegative conditions:

$d_P^{-}, d_P^{+} \geq 0, d_S^{-}, d_S^{+} \geq 0\, d_{it}^{-}, d_{it}^{+} \geq 0 \quad \forall i, t$
Nonnegative condition (97.15)
Nonnegative condition (97.23).

97.4 Numerical Examples

Here, we consider a simple supply chain contains two kinds of products ($J = 2$), one input of manufacturer ($I = 1$), two kinds of raw materials ($H = 2$), and two phases ($T = 2$). Other parameters are set as following.

$$K^{\max} = 400, G^{\max} = 600$$
$$z^{L^{\max}} = 200, y^{L^{\max}} = 200, x^{L^{\max}} = 200$$
$$z_{j0}^{L'} = y_{i0}^{L'} = x_{i0}^{L'} = 0, c_i^x = 10, c_j^z = 15 \quad \forall i, j$$
$$h_i^x = 1, h_i^y = 2, h_j^z = 3, \alpha_i^g = 1, \alpha_j^k = 1 \quad \forall i, j$$
$$s_{11}^r = 0.4, s_{21}^r = 0.6, s_{11}^y = 1, s_{12}^y = 1$$
$$o_i^x = o_i^y = o_j^z = 1, q_{it} = 90, \omega_{jt} = 200 \quad \forall i, j, t$$

Furthermore, the priority factor P_1 and P_2 are 10^5 and 100 respectively, and the expected profit of the supplier is 1×10^7. Quantities of raw materials, demands of products in certain case, and the standard market prices, are listed in Table 97.1.

According to the data listed above, we resolved the optimal solutions by using the optimization software Lingo 9.0 when demands are certain and uncertain.

(1) The case of certain demands. When demands are certain, all the optimal values of decision variables are listed in Table 97.2. The profits of manufacturer and supplier are 60160 and 36861 respectively, and the total profit of supply chain is 97021. All demands of consumer market are satisfied commendably. For semi-finished products, the delivery quantities of supplier are all equal to the order quantities of manufacturer in each phase. Therefore, the model we proposed realizes the operating cooperativeness between the members of supply chain when demands are certain.

(2) The case of uncertain demands. When the flexibility degree of demand is equal to 20 ($\rho = 20$), that is, the fluctuation interval of demand is $\left[d_{jt}, 1.2 \times d_{jt}\right]$, the operation strategies for manufacturer and supplier are shown in Table 97.3. Profits of supply chain, manufacturer and supplier are 95380, 52320 and 43060 respectively. Compared with the profits in certain case, the total profit of the supply chain decreased 1.7 %, the profit of manufacturer decreased 13.0 %, and

Table 97.1 Supplies, demands and standard prices of market

Demands and supplies		Phase 1	Phase 2
Demands in certain case	Product 1	190	195
	Product 2	197	194
Prices of ultimate product	Product 1	180	185
	Product 2	185	180
Supply quantities of raw materials	Raw material 1	336	330
	Raw material 2	335	325
Prices of raw materials	Raw material 1	30	35
	Raw material 2	35	30

Table 97.2 The optimal operating strategy of the supply chain under certain demands

Phase	Manufacturer (profit: 60160)								Supplier (profit: 36861)		
	Production (z_{jt})		Sales (v_{jt})		Inventory (z_{jt}^L)		Semi-finished product		Delivery (l_{it})	Production (x_{it})	Inventory (x_{it}^L)
	Prod. 1	Prod. 2	Prod. 1	Prod. 2	Prod. 1	Prod. 2	Inventory	Order(b_{it})			
1	190.0	197.0	190.0	197.0	0	0	0	387.0	387.0	387.0	0
2	195.0	194.0	195.0	194.0	0	0	0	389.0	389.0	389.0	0

however, the supplier's profit increased 16.8 %. This result means that the supply chain and the manufacturer may take on greater risk of excessive demands. However, in relative to the manufacturer, the supplier doesn't directly respond to the risk of excessive demands. As the order quantities of semi-finished products for manufacturer increasing when demands of ultimate products are excessive, the quantities of semi-finished products produced and delivered by the supplier increase also. Therefore, on the contrary, the profit of the supplier increases.

Further more, the data in Table 97.3 show that the quantity of semi-finished product delivered by the supplier is equal to the quantity ordered by the manufacturer at each phase. Therefore, just as the results of the case of certain demands, the model we proposed realizes the operating cooperativeness between the members of supply chain when demands are uncertain.

(3) In general, the demand range of demand fluctuation can be estimated according to historical data in practical application. Here, we use the model we proposed to calculate the profits and operational strategies of manufacturer and supplier together with the profit of supply chain system in the context of the flexibility degree of demand uncertainty takes different values of 10, 20, 30, 40, 50 separately. Profits of manufacturer, supplier and supply chain as a whole for different flexibility degrees of demand are listed in Table 97.4. The Differences to the certain case are also listed in this table.

From Table 97.4, we can find that the profits of supply chain and manufacturer under uncertain demand are less than which under certain demand, and the decrements are increasing as the degree of demand uncertainty. Both the supply chain system and manufacturer will pay much for the risk of excess demand no matter what the range of demand fluctuation is. Furthermore, when the flexibility degrees of demand is less than 50, the decrement of the supply chain system's profit is less than 2.4 %, and that of manufacturer is less than 15.3 %. Consequently, the multi-objective fuzzy programming model of supply chain coordination operation under uncertain demand developed in this paper is robust in some sense. The decision-maker can use the optimal strategies derive from this model to make optimal decision according to the degree of demand uncertainty.

97.5 Conclusion

In this paper, we considered the coordinate operating process of a class of supply chain with uncertain demands. By using fuzzy programming and multi-objective programming methods, we described the uncertainties of demands as fuzzy sets, and establish a multi-objective fuzzy programming coordinate operations model

Table 97.3 The optimal operating strategy of the supply chain under uncertain demands ($\rho = 20$)

Phase	Manufacturer (profit: 52320)								Supplier (profit: 43060)		
	Production (z_{jt})		Sales (v_{jt})		Inventory (z_{jt}^{L})		Semi-finished product		Delivery (l_{it})	Production (x_{it})	Inventory (x_{it}^{L})
	Prod. 1	Prod. 2	Prod. 1	Prod. 2	Prod. 1	Prod. 2	Order(b_{it})	Inventory			
1	195.9	204.1	195.9	203.1	0	1.0	400.0	0	400.0	400.0	0
2	201.0	199.0	201.0	200.0	0	0	505.4	105.4	505.4	505.4	0

Table 97.4 Profits of manufacturer and supplier for different ρ

Flexibility degree of demand (ρ)	0	10	20	30	40	50
The manufacturer's profit	60160	54639	52320	51546	51160	50928
Difference to the certain case	–	9.2 %	13.0 %	14.3 %	15.0 %	15.3 %
The supplier's profit	36861	41849	43060	43463	43665	43786
Difference to the certain case	–	13.5 %	16.8 %	17.9 %	18.5 %	18.8 %
The total profit of the supply chain	97021	96488	95380	95009	94825	94714
Difference to the certain case	–	0.5 %	1.7 %	2.1 %	2.3 %	2.4 %

for the supply chain. Results of numerical example testified that our methods offered in this paper can effectively deal with the impacts of demand uncertainty on supply chain performance, which can be referenced in the researches on operating uncertainties of supply chain.

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Chapter 98
A Study of Supply Chain Theory Applied in the Water Resource Market Allocation

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Abstract With the increasing shortage of water resources and pollution, the reasonable allocation of water resources has become a major field in the study of river basin ecological compensation mechanism. The market allocation of basin water resources is conducive to effective protection and reasonable exploitation of the river basin water resource. Theoretical analyses prove that market allocation of water resources show clear characteristics of supply chain. By applying the supply chain theory to water resource market allocation, the author systematically puts forward the river basin water resource supply chain concept; builds a two-layer river basin water resource supply chain model. To promote benefits, the author suggests transfer payments as a way to coordinate the river basin water resources, and calculates the standard of the payments. Finally, the policy recommendations are proposed to show that related subjects of river basin are willing to participate in river basin ecological compensation and compensation.

Keywords River basin ecological compensation · Supply chain coordination · Transfer payments · Water resource supply chain

River basin is the sum of a river (or lake) from the source to the mouth, surrounded by ground water catchment area and the underground catchment area. With water at its core, it is a complex environment and economic system, composed of

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fundamental natural elements like water, soil, living organisms, and social, economic and cultural elements as well (Feng et al. 2010). Hence, the management of water resources is a major part of ecological compensation theory and practice (Li et al. 2010). Due to regional and mobility characteristics, water basin has close relationship with the administration areas (local governments) through which the river flows. Hence, most river basins in China have a trans-boundary characteristic. And because in China, all natural resources like land and waters are state-owned, local governments are interested party, which actually makes local governments the main subjects of river basin ecological compensation.

With the study of river basin ecological compensation going further, market-based compensation mechanism of water resources is increasingly showing large-scale and systematic characteristics, which shares many similarities with the management theory of supply chain. Wang et al. (2004) studied the feasibility of water resource allocation and dispatching in the east line of South-to-North Water Diversion Project by applying supply chain. Based on supply chain and its coordination theory, this paper analyzes the two-layer (water resource) supply chain and its coordination mechanism based on game theory, and extends their application to the design of ecological compensation coordination mechanism in a trans-boundary water basin, giving some theoretical grounds for water-resource centered trans-boundary ecological compensation mechanism and policy making.

98.1 River Basin Water Resource Supply Chain and Coordination Mechanism

The conception of supply chain was first put forward in the 1980s. *Logistics Terms* defines it as "the chain formed between upstream and downstream enterprises, with one offering products and services to the other through producing and selling" (Li and Hong 2006). Supply chain can be regarded as the management pattern connecting upstream suppliers and downstream consumers, which helps achieve the supply–demand balance. The key to supply chain management is to provide the best service for the chain members at the lowest cost (Liu 2007). And the key to supply chain cooperation is the coordination between supply chain members (Wang et al. 2007). The supply chain coordination mechanism helps ensure the cooperation (Lu 2006).

In China, due to the fact that natural resources are state-owned, river basin is virtually making upstream and downstream local governments along the river an interdependent, inseparable integrated system. In some river ecological compensation practice outside China, water resources are treated as commodities in the market. Water resource market helps make water resource commodity available and also helps realize the trans-boundary redistribution of water resources. Here market refers to the trading pattern of water resource commodities, through which water resources in the river basin are redistributed. Water resource commodities include the right to use water resources and the right to dispose water wastes. Supply chain appeared in response to market economy; hence its application to water resource redistribution in the market is feasible (Becker 1995; Howitt and Hansen 2005; Johanssona et al. 2002; Weber 2001).

According to the supply chain theory, a complete supply chain should have some basic features such as network structure, being dynamic, user-oriented and interactivity. The whole basin can be regarded as a series of independent "up-downstream" subsystem under the series interwoven into the network chain structure. The subsystems connected the basin water resources into a supply-and-demand driven supply chain. In this supply chain, the upstream local government is the supplier of water resources, and the downstream local government the customer. In reality, out of natural and economic concerns, local governments often show inconsistency in the position they take and in the execution of ecological compensation. In water resource supply chain, upstream government usually supplies output, and the down stream government provides customer feedback. But this is not absolute. In this chain, the conceptions of supplier and customer are relative. The downstream local government can be the supplier of a downstream local government in another "up-downstream" subsystem, which shows the dynamic and interactivity of water resource supply chain. The formation and reconstruction of the supply chain occur as a result of customer (at all levels) demands, and the capital flow, information flow, and service flow in the supply chain are also driven by customer demands (Liu 2007).

The fact that water resource supply chain in the river basin has external diseconomy (Shah 1988) can easily result in low efficiency of the whole water resource supply chain system. Therefore, a coordination mechanism is needed to improve the overall efficiency of river basin water resources. In reality, though higher levels of government in the river basin (such as the central government, provincial government) attach importance to the establishment of ecological compensation system to strengthen ecological protection to improve ecological, economic and social benefits, local governments are relatively independent entities, with the maximum benefits being the major concern in their decision making. Therefore, it is hard to ensure that the decisions of local governments are in accordance with the entire watershed ecosystem optimization. All these call for an establishment of a coordination mechanism for the water resource supply chain. Through the construction of an effective incentive mechanism to channel the selfish decision into decisions that can best improve the whole basin water resources supply chain to achieve maximum benefits, and the key to which is to establish the water resources supply chain coordination mechanism.

98.2 Water Resource Supply Chain Coordination Model

Take one up-down stream subsystem from a water basin as an example. Defined by the feature of river basin itself, there are usually a monopoly upstream local government (controlling point A) and n $(n \geq 1)$ downstream local governments (controlling point B) in the two-layer up-down stream water resource supply chain. When $n = 1$, it is a typical chain-structure trans-boundary water resource supply chain. When $n > 1$, it is a typical network supply chain. This paper analyzes the relationship between up-down stream local governments in the two-layer water resource supply chain, while Game Theory is employed to analyze the coordination system in it (Li and Wang 2010).

98.2.1 The Model

In the two-layer water resource supply chain, there exists the monopoly upstream local government (controlling point A), and n ($n \geq 1$) downstream local governments (controlling point B). Suppose that the n downstream local governments are selling water resource products in the Cournot way of competition, the inverse demand (for water resource commodity) function of downstream local government is: $p = a - b \cdot Q$, p is the water resource commodity price offered to the downstream governments, a is the highest price for water resource in the river basin, b is a constant, and a, $b > 0$; Q is the total output of all downstream local governments' water resource commodities, expressed as $Q = \sum_{i=1}^{n} q_i$; q_i stands for the output commodity of downstream local government i. Meanwhile, if per unit of water resource commodity offered by downstream local government requires a unit of water resource commodity input by the upstream local government, and if the upstream price is w, the unit cost of upstream government is c; downstream unit cost is v; Then, the downstream local government profit π_{B_i} is:

$$\pi_{B_i} = (p - w - v)q_i \tag{98.1}$$

The profit of monopoly upstream government π_A is:

$$\pi_A = (w - c)Q \tag{98.2}$$

So the game model between up-down stream governments is described in Fig. 98.1. The game relationship can be described as: upstream local government sets the price based on the demands for water resource commodities in the market; downstream local government competes for Cournot output, and thus determines the output; the up-down stream local governments play the Stackelberg game, achieving game equilibrium.

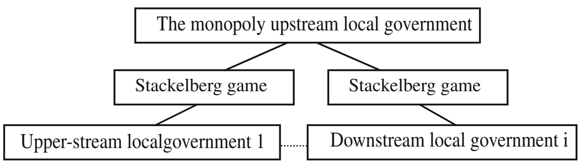

Fig. 98.1 Across administration area river basin water resource supply chain game model description

98.2.2 Independent Decision Making Under Game Solution

In traditional supply chain theory, local governments are in pursuit of maximizing their own interests when determine their respective water resource supply of goods, which can be calculated with backward induction method. The local downstream government i will see water resource commodity price w (set by upstream government) as fixed, and try to maximize his own benefit by getting the largest supply (Giannias 1997). According to Eq. (98.1), seeking a first-order condition:

Make $\frac{\partial \pi_{B_i}}{\partial q} = a - bQ - w - v - bq_i = 0$, it's:

$$q_i = \frac{a - w - v}{(n+1)b} \tag{98.3}$$

$$Q = \sum_{i=1}^{n} q_i = \frac{n(a - w - v)}{(n+1)b} \tag{98.4}$$

To put (98.4) into (98.2), the result is:

$$\pi_A = \frac{n(w - c)(a - w - v)}{(n+1)b} \tag{98.5}$$

Make $\frac{\partial \pi_A}{\partial w} = \frac{n(a - 2w - v + c)}{(n+1)b} = 0$, it's:

$$w = \frac{a - v + c}{2} \tag{98.6}$$

So the result of equilibrium is:

$$q_i = \frac{a - v - c}{2b(n+1)}, \quad Q = \frac{n(a - v - c)}{2b(n+1)}, \quad w = \frac{a - v + c}{2}, \quad \pi_A = \frac{n(a - v - c)^2}{4b(n+1)}, \quad \pi_{B_i} = \frac{(a - v - c)^2}{4b(n+1)^2},$$

So:

$$\pi = \pi_A + \sum_{i=1}^{n} \pi_{B_i} = \frac{n(n+2)(a - v - c)^2}{4b(n+1)^2} \tag{98.7}$$

The analyses of the result of equilibrium reveal that the lower the commodity production costs v and c are the more profit upstream governments get. And therefore, all local governments should make endeavor to cut down the cost so as to get more profit; meanwhile, all local governments should better their water resource commodity service so as to enlarge the capacity and demands of the entire water resource market, which means gaining more profits by raising a, the price of water resource commodities. On the other hand, with the value of n being high, the profit margin of downstream local government is slim, upstream local government, however, profits more, adding to the overall profit of the whole supply chain.

98.2.3 Game Solution Under Centralized Decision Making

If the upstream and downstream cooperation can be coordinated and reinforced, both take the entire basin water resource supply chain system's maximum benefit as the starting point while deciding their behavior, the solution can be obtained with backward induction method:

When all the upstream, downstream governments' decision about w is meant to maximize the benefit of the whole water basin water resource supply chain, with the Eq. $\pi = \pi_A + \sum_{i=1}^{n} \pi_{B_i}$, it's:

$$\begin{aligned} \pi = \pi_A + \sum_{i=1}^{n} \pi_{B_i} &= (a - bQ - v - c)Q \\ &= \frac{n(a - w - v)[(a - v + nw - (n+1)c)]}{b(n+1)^2} \end{aligned} \tag{98.8}$$

Make: $\frac{\partial \pi}{\partial w} = 0$, it's:

$$w^* = \frac{(n-1)(a-v) + (n+1)c}{2n}, \tag{98.9}$$

So the result of equilibrium is:

$$\begin{aligned} q_i^* &= \frac{a-v-c}{2bn}, \quad Q^* = \frac{a-v-c}{2b}, \\ w^* &= \frac{(n-1)(a-v) + (n+1)c}{2n}, \\ \pi_A^* &= \frac{(n-1)(a-v-c)^2}{4nb}, \quad \pi_{B_i}^* = \frac{(a-v-c)^2}{4n^2 b}, \\ \pi^* &= \pi_A^* + \sum_{i=1}^{n} \pi_{B_i}^* = \frac{(a-v-c)^2}{4b}, \end{aligned}$$

So:

$$\Delta\pi_A = \pi_A^* - \pi_A = -\frac{(a-v-c)^2}{4bn(n+1)} < 0 \tag{98.10}$$

$$\Delta\pi_{B_i} = \pi_{B_i}^* - \pi_{B_i} = \frac{(2n+1)(a-v-c)^2}{4bn^2(n+1)^2} > 0 \tag{98.11}$$

Hence,

$$\Delta\pi = \pi^* - \pi = \frac{(a-v-c)^2}{4b(n+1)^2} > 0 \tag{98.12}$$

According to (98.12), when $\pi^* > \pi$, it means that centralized decision making can increase the benefit of water resource supply chain, but when $\pi_{Bi}^* > \pi_{Bi}$, $\pi_A^* < \pi_A$, it means that centralized decision making is more favorable for downstream local government, but it's unfavorable to upstream local government, which is not acceptable for upstream local government.

98.2.4 Water Resource Supply Chain Coordinated with Transfer Payments

The above analyses show that the cooperation between the upstream and downstream governments is more beneficial to increase the profit of the whole water resource supply chain. For the upstream local government to accept this kind of cooperation, the downstream local government needs to pay water resource commodity transfer costs to the upstream local government. If t stands for transfer costs, then it is required that:

$$\begin{cases} \pi_A^* + t \geq \pi_A \\ \sum_{i=1}^{n} \pi_{B_i}^* - t \geq \sum_{i=1}^{n} \pi_{B_i} \end{cases} \Rightarrow \begin{cases} \dfrac{(n-1)(a-v-c)^2}{4nb} + t \geq \dfrac{n(a-v-c)^2}{4b(n+1)} \\ \dfrac{(a-v-c)^2}{4nb} - t \geq \dfrac{n(a-v-c)^2}{4b(n+1)^2} \end{cases} \tag{98.13}$$

Solution:

$$t \in \left[\frac{(a-v-c)^2}{4nb(n+1)}, \frac{(2n+1)(a-v-c)^2}{4nb(n+1)^2}\right] \tag{98.14}$$

When the value of t falls in the range of $\left[\frac{(a-v-c)^2}{4nb(n+1)}, \frac{(2n+1)(a-v-c)^2}{4nb(n+1)^2}\right]$, both upstream and downstream benefit more from centralized decision than from independent decisions. Meanwhile, the smaller n is (i.e. the fewer downstream local governments there are), the more obvious the advantages (of centralized decision making) are, and the bigger the range of value t (transfer payment) is, which proves that centralized decision making are more suitable for water resource supply chain with fewer downstream local governments in the water basin. This happen to be consistent with the actual situation of most water basins, for, as a matter of fact, there are virtually aren't many local governments of the same administrative level in the "up-down steam" subsystems. And this further proves the water resource supply chain theory to be valid, rational and highly feasible.

Table 98.1 Imulation table

	n	Independent decision making			Centralized decision making			
		π_A	π_B	π	$\Delta\pi_A^*$	$\Delta\pi_B^*$	$\Delta\pi$	t
a = 4, b = 1	1	0.125	0.063	0.188	−0.125	0.188	0.063	[0.125, 0.188]
a = 4, b = 1	2	0.167	0.028	0.222	−0.042	0.035	0.028	[0.042, 0.069]

98.2.5 Model Exemplification

A case is cited here to further verity the model. In the exemplification, make $v = 2$, $c = 1$, then the corresponding results can be seen in Table 98.1. As is shown in Table 98.1, the results of the simulation accord with all the above discussions and conclusions.

98.3 Conclusion

By applying supply chain theory and its coordination concept to trans-boundary water basin eco compensation mechanism, a chain-structured and a network-structured water resource supply chain model are established. The analyses of the models show that cooperation between upstream and downstream local governments (centralized decision making for water basin eco protection and compensation) help improve benefits of the overall water resource supply chain. This, however, will impair the benefits of upstream local governments. Moreover, upstream local governments enjoy ecological and information priority. So for the cooperation to be accepted by upstream local government who is in monopoly position, a kind of coordination mechanism is needed as an incentive for upstream local governments to take the initiative to cooperate. As a means of coordination, downstream government, who benefit from eco protection (done by upstream local government), should pay transfer cost t (seen as ecological compensation cost) to upstream local government, so that both sides can benefit more than when they make independent decisions (Wang et al. 2004; Li and Hong 2006; Liu 2007). Active cooperation (centralized decision making) can optimize the benefits of water resource supply chain.

It should be noted that given the importance of t value, in water resource market, both upstream and downstream governments will tend to bargain concerning t value. The marketization of China river basin ecological compensation mechanism and water resource market are still not market in the real sense, but a "quasi market" under the control of the government (Wu and Zhao 2011). Due to the uneven development among different local governments, the superior government (such as the central government and provincial government) must intervene in transfer payment and compensation framework negotiation. Through the introduction of quasi market mechanism, construct the basin water resource commodity market trading patterns which combines the right to draw on water resources and the right to discharge polluted water; explore the horizontal transfer payment system, in which the central government (or the relevant competent departments) takes the lead and the local governments at all levels take the responsibility. Make an endeavor to establish complete legal laws and regulations, rigid reward and punishment mechanism and a sound regulatory system, to regulate river basin water resource market behavior. Enhance ecological protection concerns and investment, and achieve sustainable development by improving the comprehensive benefits of water resources in the river basin.

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Chapter 99
An Improved Genetic Algorithm for Location Problem of Logistic Distribution Center for Perishable Products

Xue Chen and Cong-you Zhong

Abstract This paper describes an improved genetic algorithm for solving location problem of logistic distribution center for perishable products when restrictive area exists. The model considers the impact of the perishability as part of the overall distribution cost, and a heuristic approach on sub distribution areas and feasible routes is combined with genetic algorithm to solve the problem. Computational results are reported on location problem of logistic distribution center derived from benchmark instances with restrictive area.

Keywords Genetic algorithm · Location · Logistic distribution · Perishable products

99.1 Introduction

In this paper, we consider the location problem of logistic distribution center for perishable products, where there are restrictive areas like lakes or administrative areas. This problem has received some attention. For example, Goyal and Giri (2001) divided perishable products into two categories, one is the products whose value become low along with technology development or introduction of competitor's new products; the other is the products spoiled with time. China, because of the lag of our logistics technology and management, has got a great loss every year on the second category (Liu and Li 2008).

Logistic distribution center plays an important role in the supply chain network. Different solutions to location problem of distribution center are generated (Osvald and Strirn 2008; Nabila et al. 2007; Tarantiles and Kirannoudis 2001; Jiang and

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Yang 2003; Wang et al. 2008; Yang et al. 2011; Huang et al. 2009; Louis et al. 2002; Mikko and Juha 2001). In (2008), Osvald and Stirn put forward a vehicle routing model of perishable products with time windows and solved it with heuristic algorithm. Nabila and Michel studied routing problem of single vehicle repeatedly distribution for perishable products, and introduced the initial shortest path algorithm with restraint in (Nabila et al. 2007). Tarantilis and Kirannoudis introduced a heuristic algorithm based on permutation routing panel point which solved the distribution problem of perishable products in Tarantiles and Kirannoudis (2001).

In this paper, a heuristic algorithm for solving location problem of logistic distribution center with restrictive areas is reported. A new method of distribution areas and feasible path is combined with genetic algorithm to solve the problem. In Sect. 99.2, a mathematical model is set up, and the formulation is proposed. The method of distribution areas and feasible path is designed and combined with genetic algorithm in Sect. 99.3. Computational results on classical location problem of logistic distribution center with restrictive area are reported in Sect. 99.4. Concluding remarks follow in Sect. 99.5.

99.2 Mathematical Model and Formulation

99.2.1 Problem Description

The problem considered can be stated as follows. In a supply chain network with some restrictive areas, suppliers and customers are predefined; we are made to solve the location problem of distribution center to optimize the supply chain network. The optimization objects are reducing the impact of the perishable products and the cost of whole supply chain network.

We assume that any perishable product has a limited lifespan which is divisible into three stages. The point $t = 0$ represents the optimal condition of the perishable product, where the quality rate $\delta = 1$ (from 0 to T_0 in Fig. 99.1). At point T_0 visible changes start in one or more of the quality parameters. During the second stage (from T_0 to T_1 in Fig. 99.1), the visible changes continue, the quality rate δ decreases linearly with time and at point T_1 the product starts to be unacceptable. When it comes to the third stage, the rate δ decreases near to zero and the product is no longer acceptable.

99.2.2 Mathematical Mode and Problem Formulation

The fundamental assumptions can be stated as follows:

- The resources condition of product and distribution centers of supply chain network are the same. One customer can be served by one distribution center.

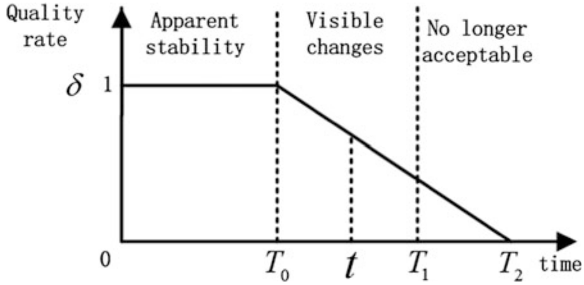


Fig. 99.1 Real and apparent quality loss with time

- The capacity of logistic distribution center can meet the demand, and the loading and unloading time during logistics can be ignored.
- The needs of all customers are predefined. The transportation speed among all nodes is calculated as average speed v which is constant.
- The entire cost should contain construction cost of the distribution center, perishable products loss and transportation cost.
- The impact of the perishability is considered as part of the overall distribution cost.

The supply chain network system can be described with the coordinate. For example, there are a set of customer nodes $M_i(x_i, y_i)$ in the graph $(i = 1, 2, 3\ldots m)$, we have to locate the distribution centers from a set of nodes $N_j\left(x_j, y_j\right)$ in the graph $(j = 1, 2, 3\ldots n)$. A distance d_{sji} describes that products move from supplier s to the customer M_i through distribution center N_j. Each customer $i \in M$ is characterized by a quantity demanded u_i, and the actual quantity delivered from the supplier is U_{sji}. The travel time t_{sji} is associated with the distance d_{sji} and the average speed v. Because the impact of perishability is considered, the quality rate δ_{sji} is the most important parameter which could describe the loss during transportation. L_{si} is the quantity loss during transportation from supplier to the customer. Every customer in the supply chain network must be served in a certain time which associated with the location of the distribution center. The construction cost of the distribution center F_j is also an important factor, which is affected by building cost and maintenance cost. So we take them as the major factors of the construction cost. The objective is to minimize the whole cost of the supply chain network to serve all customers while satisfying the capacity, perishability, cost and time.

This problem can be formulated as follows:

$$Fit1 = \min[A + B + C] \tag{99.1}$$

$$\text{s.t.}\, A = \sum_{j=1}^{n} \sum_{i=1}^{m} \left[U_{sji}\left(d_{sj}c_1 + d_{ji}c_2\right)\right]A_{ij} \tag{99.2}$$

$$B = \sum_{j=1}^{n} F_j B_j \tag{99.3}$$

$$C = \sum_{i=1}^{m} c_3 L_{si} \tag{99.4}$$

$$d_{ji} = \sqrt{\left(x_i - x_j\right)^2 + \left(y_i - y_j\right)^2} \tag{99.5}$$

$$A_{ij} binary, \text{if } N_j \text{ is located} \tag{99.6}$$

$$B_j binary, \text{if } N_j \text{ is located} \tag{99.7}$$

$$F_j = c_4 + c_5 \sum_{j=1}^{n} \sum_{i=1}^{m} U_{sji} \tag{99.8}$$

$$t_{sji} = d_{sji} / v \tag{99.9}$$

$$\delta_{sji} = \begin{cases} \frac{\left(T_2 - t_{sji}\right)}{\left(T_2 - T_0\right)} & T_0 < t_{sji} < T_1 \\ 1 & t_{sji} \le T_0 \\ 0 & t_{sji} \ge T_1 \end{cases} \tag{99.10}$$

$$U_{sji} = \frac{u_i}{\delta_{sji}} \tag{99.11}$$

$$L_{si} = U_{sji}\left(1 - \delta_{sji}\right) = \frac{u_i\left(1 - \delta_{sji}\right)}{\delta_{sji}} \tag{99.12}$$

where

- A_{ij} is 1, if N_j is the distribution center, 0 otherwise; note that the number of distribution centers may be more than one;
- B_j is 1, if N_j is the distribution center, 0 otherwise;
- c_1 is the parameter of the transportation cost from supplier to distribution center; c_2 is the parameter of the transportation cost from distribution center to the customer;
- c_3 is the parameter of the product cost;
- c_4 is the parameter of the building cost of the distribution center; note that c_5 is the parameter of the maintenance cost which is affected by the capacity.

In this formulation, Eqs. (99.2) and (99.11) state the transportation cost of the supply chain network. Equations (99.3) and (99.8) state the construction cost which is affected by building cost and maintenance cost. Equations (99.4) and (99.12) state the perishable products loss.

99.3 Genetic algorithm

Usually there are some geographic environment factors which affect the location problem of logistic distribution center, such as lakes, city greenbelt or administrative areas. However, the traditional genetic algorithm can not solve these practical problems well. In this section we take sub distribution areas and feasible routes into account to solve the problem.

99.3.1 Chromosomes and Coordinates

Chromosomes are designed to be composed of the coordinates of customers and distribution centers. For example, the chromosome $g = (k_1, k_2, \ldots, k_i, \ldots, k_m, k_j, \ldots, k_n)$, k_i is the coordinate of the customers $M_i(x_i, y_i)$, while k_j is the coordinate of the distribution center $N_j(x_j, y_j)$. In this paper the map is disposed with classical image processing methods. The coordinate is measured by a suitable scale.

99.3.2 Fitness Function

Fitness function is the most important factor which decides convergence and stability of genetic algorithm. Here, we design the fitness function with punishment parameter to increase convergence. An operator R_T is also designed to detect the feasible routes in each sub distribution area.

The fitness function could be stated as follows:

$$FitV = Fit1 + c_6 \times F_{cst} \tag{99.13}$$

$$\text{s.t.}\, Fit2 \text{ binary, if } R_T \text{ is true} \tag{99.14}$$

$$F_{cst} = \sum_{j=1}^{n} \sum_{k_i \in S_j} Fit2 \times L(j) \tag{99.15}$$

where

- $Fit2$ is 1, if R_T is true, all routes are feasible, 0 otherwise;
- c_6 is a constant parameter which is associated with the punishment factor;
- $Fit2$ is 1, if R_T is true, all routes are feasible, 0 otherwise;
- S_j is the sub distribution area which could serve the customers; note that $N_j(x_j, y_j)$ is the distribution center;
- The route from distribution center to customer is the shortest path; the feasible route is the path which does not cross the obstacles such as administrative areas;

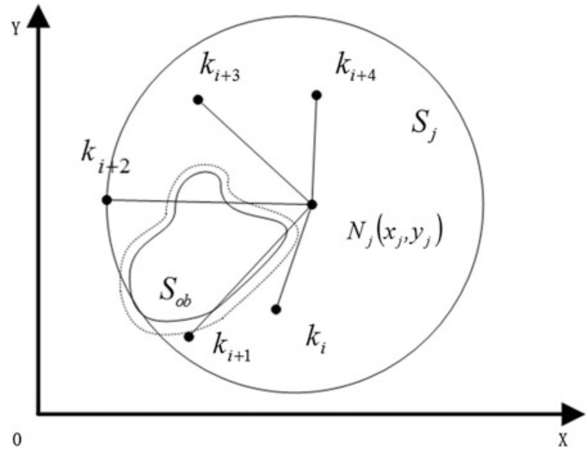


Fig. 99.2 Example of a typical sub distribution area

- $L(j)$ is defined as obstacle length which is the sum length of the path crossing the obstacles; note that if all routes are feasible, $L(j)$ is zero;
- R_T is the detection operator which calculates the punishment factor; if the route is feasible, it returns 1, 0 otherwise.

The sub distribution area S_j, which is composed of the distribution center $N_j(x_j, y_j)$ and five customers $k_i, \ldots, k_{i+4}$, is shown in Fig. 99.2 There is an obstacle S_{ob} in this distribution area. According to the definition of $L(j)$, we can get the result from Fig. 99.2

$$L(j) = d_{ji+1} + d_{ji+2} \tag{99.16}$$

Equation (99.13) states the fitness function of the improved genetic algorithm. The punishment factor F_{cst} is calculated when the routes are irrational. If all the routes are feasible, the punishment factor F_{cst} is zero, otherwise it will be a positive value which is associated with the unfeasible routes.

99.3.3 Cross and Metamorphosis

As shown in Fig. 99.2, the fitness function of the distribution area S_j can be calculated. During the computing process of the genetic algorithm, P_c and P_m are calculated in every generation. The method to confirm P_c and P_m is from the adaptive genetic algorithm of Srinivas and Patnaik (1994).

$$P_c = \begin{cases} \frac{k_1(f_{\max} - f')}{f_{\max} - f_{avg}} & f' \geq f_{avg} \\ k_2 & f' < f_{avg} \end{cases} \tag{99.17}$$

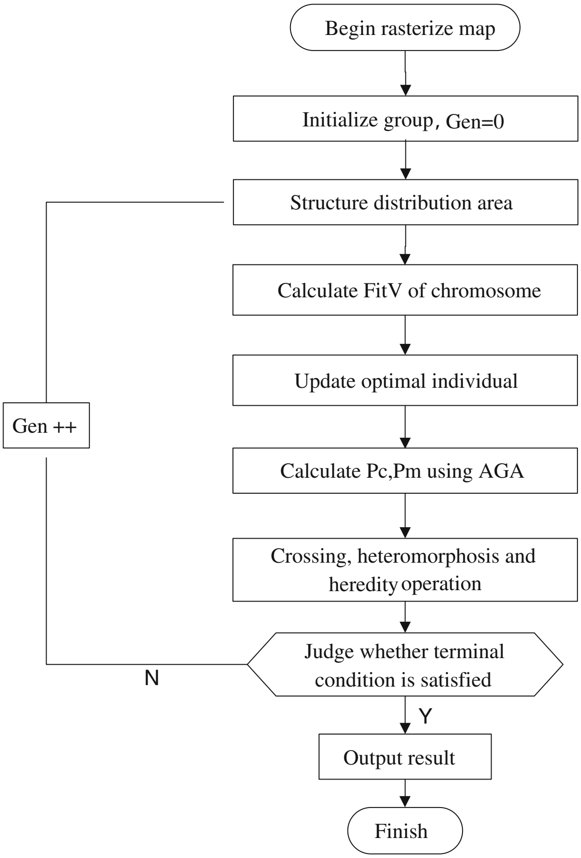
$$P_m = \begin{cases} \frac{k_3(f_{\max} - f')}{f_{\max} - f_{avg}} & f' \geq f_{avg} \\ k_4 & f' < f_{avg} \end{cases} \quad (99.18)$$

$f_{\max}$ is the maximum fitness function of the group, f_{avg} is the average fitness function of the group, f' is the bigger one of the two individuals that participate in the genetic operation. k_1, k_2, k_3, k_4 are constant and the value of each one is less than 0.1.

99.3.4 Solution of the Problem

The procedure of location problem of logistic distribution center for perishable products based on improving genetic algorithm is shown in Fig. 99.3.

Fig. 99.3 Procedure of the improved genetic algorithm



99.4 Experiments and Analysis

To evaluate the performances of the proposed genetic algorithm, we perform the following test. A region which has a lake and an administrative area is made into a [100 × 100] map. The candidate distribution centers and customers are randomly scattered in the area.

- v is set from [2, 4] randomly as the average speed; c_1, c_2, c_3, c_4 is also randomly set;
- Every customer's quantity demanded is set from [10, 20] randomly; the coordinate of the supplier is in the center of the map;
- The quality rate parameters of perishable products are $T_0 = 24$, $T_1 = 48$, $T_2 = 72$.

To evaluate the algorithm, we take an example of (15, 30) that the number of candidate distribution centers is 15 and the number of the customers is 30. The optimal process of the fitness function in this example is shown in Fig. 99.4 where we also notice that the calculating process of the algorithm is converged rapidly.

Tables 99.1, 99.2, 99.3 and 99.4 present the results of the example (15, 30). In these tables we report:

The optimal distribution centers for location problem in example (15, 30) are No. 3, No. 6, No. 12, and No. 13. Because the original group is random, the original value of fitness function is a high positive value. At the 11th generation, the detection operator of the algorithm gets feasible routes, and the punishment factor returns zero, so the value of fitness function gets a typical decline. Finally the algorithm obtains the optimal solution at the 112th generation.

According to the results above, we have gotten the solution of the example (15, 30). As shown in Fig. 99.5 the solution to the problem is effective and rational, where the supply chain network avoids restrictive areas which contain a lake and an administrative area.

Fig. 99.4 Fitness of function with generation

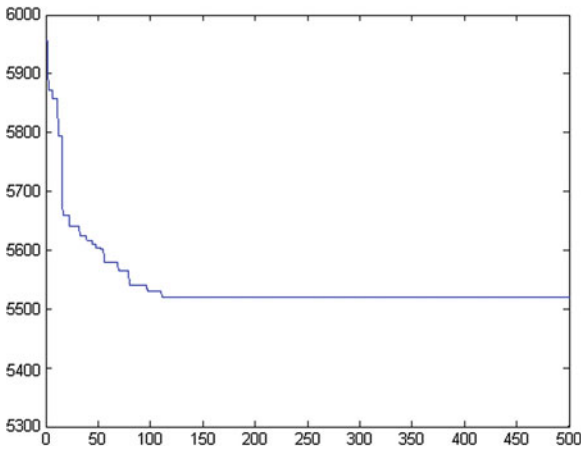


Table 99.1 Data of distribution centers and customers

Customer number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Location coordinate	7,4	23,3	43,7	60,3	76,5	87,9	6,17	22,16	34,18	53,23	94,33	14,26	6,45	23,44	40,37
Quantity demanded	12	14	18	19	11	15	10	20	18	12	14	19	19	13	10
Customer number	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Location coordinate	59,43	78,52	89,48	41,49	2,62	49,58	67,66	85,65	29,82	38,75	50,76	59,80	49,92	74,89	90,84
Quantity demanded	14	17	16	17	11	15	13	12	19	15	20	11	10	17	19

Table 99.2 Parameters of the example

Calculating parameters	c_1	c_2	c_3	c_4	v
Value	0.03	0.05	2.1	0.6	1.8

Table 99.3 Results of the example

Optimal solution	Optimal generation	Number of location	Total cost
Value	112	4	5540.256

Table 99.4 Results of distribution center

Serial number	3	6	12	13
Construction cost	240.79	321.01	283.81	259.17
Waste value	20.328	53.525	37.195	27.027

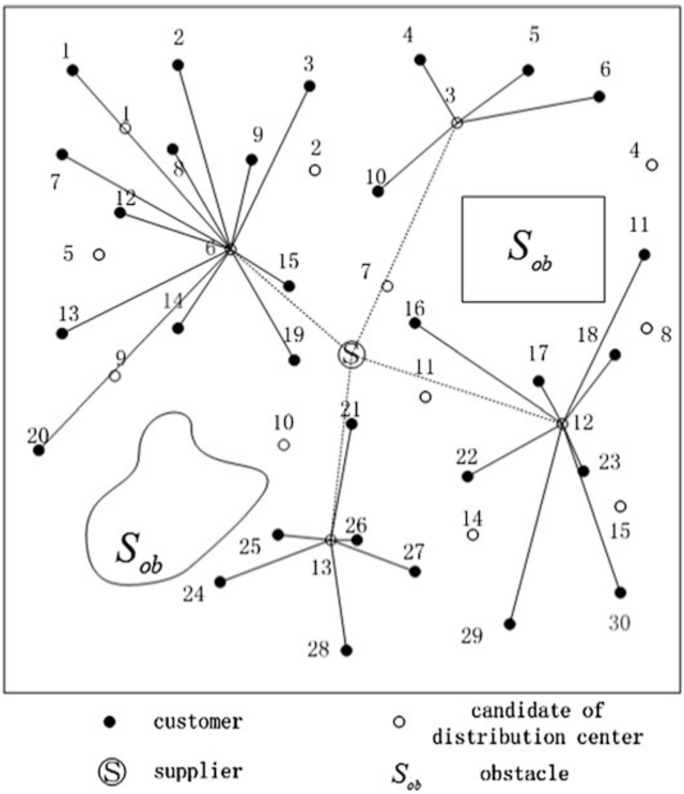


Fig. 99.5 Optimal result for the location problem in example (15, 30)

99.5 Conclusions

This paper has described an improved genetic algorithm for location problem of logistic distribution center for perishable products. The results indicate that this algorithm is effective to the instances with restrictive area. The fitness function with punishment factor is designed to increase convergence and solve the location problem. Future developments will now be aimed at considering problems that are closer to real-world applications. The assumptions of capability and more suppliers will be considered, and then more complex problems will be studied, where more customer requests are integrated.

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Chapter 100
Analysis of Supply Chain System Optimization on the Basis of Quality Function Deployment

Chang Liu

Abstract This work researches on supply chain system of the process of Automobile Manufacture Enterprise's mass customization by using the method of QFD and reconstructs its HOQ, analyzes and compares the main factors deciding supply china system capability. At the basis of all of these, it put forward the improving measure and the method of optimizing supply chain system capability in order to advance service level and quality of supply chain system and further effectively satisfy the customer demand and enhance market shares.

Keywords House of quality (HOQ) · Mass customization · Quality function deployment (QFD) · Supply chain system

100.1 Introduction

Quality function deployment (QFD) is a planning tool, followed by QFD method which can express the relationship between quality characteristics and quality requirements for customers (Hauser and Clausing 1988). House of quality convert customer requirements to supply chain technology requirement in mass customization and use supply chain service factor characteristics to express the requirements (Cui and Sun 2006; David et al. 1999; Zhou et al. 2005). This conversion can provide a series of waterfall decomposition research of supply chain system cost, marginal profit control analysis and corresponding parameters (Eleonora and Antonio 2006). Fuzzy comprehensive evaluation method is based on the fuzzy mathematic evaluation method. This evaluation method transform qualitative

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evaluation into quantitative evaluation, fuzzy math is used to make an overall evaluation of many factors or objects (Zeithaml et al. 1990).

In the current market globalization, the competition among the enterprises have been the focus of concentrated on how to satisfy the diverse needs of customers and this has put forward higher requirements of the manufacturing enterprise supply chain system (Smith 2008). Nowadays, competition among enterprises become more and more intense in order to get further reducing of costs and meet the needs of customers. People will transform their sight from enterprise interior management to product life cycle of the supply chain and the supply chain system (Chien and Tsai 2000). With the purpose of a quick response to the market, increasing the flexibility and reducing costs, supply chain management idea has been widely accepted by the global business and management academics and achieved great economic benefits. How to succeed in the market of supply chain is the meaningful research for supply chain management (Li 2002).

In this paper, apply this method to analyze supply chain system performance and the corresponding parameters of an automobile enterprise, and give an practical conclusion. The whole process of QFD can meet market demand and the input and output of HOQ are driven by market demand, in order to ensure satisfying the maximum the market requirements of customers.

100.2 Methodology

100.2.1 Construction of HOQ

Supposing that there are x customers in supply chain system A, they put forward several technical requirements and transform them into service factor $CR_i\,(i = 1, 2, \ldots, n)$. According to CR_i, system puts forward strategy method called $ER_j\,(j = 1, 2, \ldots, m)$. Then, the system itself evaluates correlation between CR_i and ER_j. The evaluation matrix is $[R_{ij}]\,(i = 1, 2, \ldots, n; j = 1, 2, \ldots, m)$, wherein R_{ij} is related to the correlation coefficient matrix. The structure of house of quality consists of 6 parts which is supply chain service factor changed from customer demand, supply chain technology strategy, relationship matrix $[R_{ij}]$, conclusion analysis, importance weights and roof correlation (So and Choi 2001) and service factor (Rothwell and Gaediner 1989; Senge 2002; Li 2004). The roof correlation usually adopts a set of symbols to represent the customer needs transforming into degree of correlation between service factor and supply chain strategies. For example, if there exists a relationship between two supply chain strategy methods (ER_1 and ER_2), the improving of ER_1 will surely bring negative changes of ER_2. We can use a symbol such as "↓" to represent this kind of situation, and it is called negative correlation. On the contrary, the situation with the improvements of ER_1 bring positive changes of ER_2 and this can be called positive correlation; using a symbol such as "↑" to say this kind of situation, and being referred to as a positive correlation. A situation whereby the degree of correlation in strategy methods is strong shows that the improvement of technology can satisfy customers' needs. This correlation matrix can intuitively explain whether they have properly covered the customer needs or not. If there are little related symbols or too more negative related symbols in the correlation matrix, it means the technology needs are not enough to meet the customers' needs and they should be amended (Hardcatle 1983; Ma et al. 2000).

100.2.2 Triangular Fuzzy Algorithm

Applying triangular fuzzy algorithm and convert the importance of fuzzy language, the No. x customer with the No. i service factor (CR_i) can be expressed as a fuzzy triangle number $w_{i,x}$ and $w_{i,x} = (l, m, u)$. Supply chain services factor importance designated I_x, with 'x' number of customers and relative weight of HOQ can be expressed as W_i:

$$W_i = \sum_{x=1}^{n} I_x \otimes w_{i,x} (i = 1, 2, \ldots, n) \quad (100.1)$$

Relative weight W_i: We use the relative weight to reflect sorting situation of various customers' needs clearly. Absolute weight:

$$W_i^* = d_i \otimes W_i (i = 1, 2, \ldots, n) \quad (100.2)$$

W_i^* is the absolute triangular fuzzy number of service factor. This value can provide a quantitative evaluation of service factors' absolute weight.

In this equation,

$$d_i = \int_x |\mu_A(x) - \mu_B(x)| dx. \quad (100.3)$$

d_i belongs to the direct distance of two fuzzy A and B, $d(\mu_A(x), \mu_B(x))$.

Relative importance (RI_j) can express how important strategy method put forward by the supply chain system according by service factor is. That is to say, it is a triangular fuzzy number related to the importance of strategy method.

$$RI_j = \sum_{i=1}^{n} W_i^* \otimes R_{ij} (j = 1, 2, \ldots, m) \quad (100.4)$$

$[R_{ij}]$ is the correlation matrix. Absolute importance (RI_j^*) can be expressed as:

$$RI_j^* = RI_j \oplus \sum_{k=j} T_{kj} \otimes RI_k (j = 1, 2. \ldots . m). \quad (100.5)$$

RI_j^* refers to triangular fuzzy numbers which describe the true important degree of strategy method. T_i is the target value of this enterprise which is formulated according to the maximize limiting of actual situation, production capacity and supply chain system of enterprises. Each strategy has its target value. In order to assess and classify strategy method, introduce execution cost (C_j), which is the execution cost of No. j. Thus, the marginal profit (U_j) of strategy method can be expressed as:

$$U_j = RI_j^* \otimes \frac{1}{C_j} (j = 1, 2, \ldots, m) \tag{100.6}$$

In order to compare effects of strategy method, we introduce variable D_f, which is expressed by eliminated fussy number of marginal profit.

$$D_f = (l + 2m + u)/4 \tag{100.7}$$

l, m and u is all the fussy number of U_j.

100.3 Application of Fussy QFD Supply Chain System in Automobile Industry

100.3.1 Determination of the Index System

Aiming at the requirement in the automobile supply chain system, establish the industry supply chain system service factor index CR_i including the completion of the production of lean time (LT), flexible order regulation (FOR), order's accuracy completing (FAC), symmetry of supply chain information (SSCI), product quality and credibility (PQC), efficiency optimization (EO), network optimization (NO) and customer complaint management (CCM). Detail description is shown in Table 100.1. According to service index, the automobile industry establishes its strategy method (ER_j) including just in time (JIT), order optimization mechanism (OOM), information technology optimization (ITO), demand forecasting (DF), customer relationship management (CRM), warehouse location optimization (WLO), optimization of inventory control (OIC) and transportation decision optimization (TDO). Detail description is shown in Table 100.1.

100.3.2 HOQ Establishment and Analysis

Judging from service factor and strategy factor evaluated by the industry itself, we apply triangular fuzzy theory to describe evaluation standard by fuzzy terms. VH present high level of customer's request in the fuzzy language with fuzzy value

Table 100.1 Description of service factor and strategy method

Strategy method	Description
JIT	Provide parts by right quality in time
OOM	Satisfy customer's order requirement
ITO	Exchange information by information system
DF	Forecast customer's requirement
CRM	Applying net work to manage customer's relationship
WLO	Optimize location of inventory
OIC	Control inventory cost by production plan
TDO	Choose best transportation tool and way
Service Factor	
LT	Time interval from order to get products
FOR	Ability of control the number of order and time
FAC	Ability of avoiding mistakes and damages in the process
SSCI	Supply chain information sharing degree
PQC	Ability of accomplishing orders in predicting time
EO	Unite time to complete the orders
NO	Optimize location of distributor and information
CCM	Establish new service principle according to customers' complain

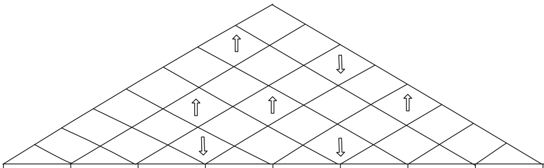
(0.7; 1; 1); H represents high level with fuzzy value (0.5; 0.7; 1); M represents the general level with fuzzy value (0.2; 0.5; 0.8); L represents the low level with fuzzy values (0; 0.3; 0.5); VL represents a very low level with fuzzy value (0; 0; 0.3). Five mass customized customers can be sorted naturally from customer 1 to customer 5 according to the level of service factor importance and the degree of supply chain service factor importance are 0.4, 0.3, 0.15, 0.1 and 0.05 respectively. Each customer will evaluate his eight service factors to show his fuzzy level, and translates them into fuzzy language. Service factor fuzzy triangular values are shown in Table 100.2.

The fuzzy product (⊗) of service factor fuzzy evaluation value and the importance of each customer is the relative weight of service factor, then, we can get the absolute weight. The fuzzy product of judgment matrix compared by eight service factors and eight strategy factors and service factor absolute weights is the strategy method relative importance, then, we can get the absolute importance. The enterprises assesses its fuzzy cost on the supply chain strategy, calculate each marginal profit of strategy method according to the absolute importance and get fuzzy values and the maximum limit on the basis of the enterprise's actual situation, production capacity and supply chain system. Comparing and analyzing the target value of each strategy method and the fussy value, we can eventually build a house of quality shown in Fig. 100.1.

From the figure of automobile enterprise, eliminating fuzzy value and target value analysis results, we can find three indicators—node 2, 3 and 6 (optimization strategy, information technology and warehouse site selection optimization) reached the service factor requirements strategy method target value of the enterprise, while other five indices failed to reach the goal. These five indices can

Table 100.2 Service factors' importance and fussy triangular values

Service factor	Customer	LT	FOR	FAC	PQC	EO	CCM	SSCI	NO
Importance	Customer 1	VH	H	VH	VH	H	L	VH	H
	Customer 2	H	M	H	VH	M	H	H	VH
	Customer 3	L	VL	M	H	L	VH	L	H
	Customer 4	L	VH	VL	M	VL	VL	L	M
	Customer 5	VL	VL	L	L	VL	VL	VL	L
Fuzzy triangular value	Customer 1	(0.7; 1; 1)	(0.5; 0.7; 1)	(0.7; 1; 1)	(0.7; 1; 1)	(0.5; 0.7; 1)	(0; 0.3; 0.5)	(0.7; 1; 1)	(0.5; 0.7; 1)
	Customer 2	(0.5; 0.7; 1)	(0.2; 0.5; 0.8)	(0.5; 0.7; 1)	(0.7; 1; 1)	(0.2; 0.5; 0.8)	(0.5; 0.7; 1)	(0.5; 0.7; 1)	(0.7; 1; 1)
	Customer 3	(0; 0.3; 0.5)	(0; 0; 0.3)	(0.2; 0.5; 0.8)	(0.5; 0.7; 1)	(0; 0.3; 0.5)	(0.7; 1; 1)	(0; 0.3; 0.5)	(0.5; 0.7; 1)
	Customer 4	(0; 0.3; 0.5)	(0.7; 1; 1)	(0; 0; 0.3)	(0.2; 0.5; 0.8)	(0; 0; 0.3)	(0; 0; 0.3)	(0; 0.3; 0.5)	(0.2; 0.5; 0.8)
	Customer 5	(0; 0; 0.3)	(0; 0; 0.3)	(0; 0.3; 0.5)	(0; 0.3; 0.5)	(0; 0; 0.3)	(0; 0; 0.3)	(0; 0; 0.3)	(0; 0.3; 0.5)



	JIT	OOM	ITO	DF	CRM	WLO	OIC	TDO	Relative Weight Wi	Absolute Weight Wi*
LT	(0.7;1;1)	(0.7;1;1)	(0.7;1;1)	(0.7;1;1)		(0.2;0.5;0.8)			(0.21;0.18;0.22)	(2.6;3.6;3.2)
FOR	(0.5;0.7;1)		(0;0;0.3)	(0;0;0.3)	(0.7;1;1)		(0.2;0.5;0.8)	(0.7;1;1)	(0.16;0.2;0.12)	(1.2;1.8;1.7)
FAC	(0.2;0.5;0.8)	(0.7;1;1)	(0.7;1;1)		(0.2;0.5;0.8)	(0.2;0.5;0.8)			(0.31;0.24;0.24)	(0.82;1.6;1.26)
SSCI		(0.2;0.2;0.46)	(0.7;1;1)		(0.2;0.05;1.28)	(0.5;1.4;2.6)	(0.7;1;1)		(0.15;0.2;0.16)	(0.05;0.16;1.26)
PQC	(0.7;1;1)		(0.2;0.5;0.8)		(0;0;0.3)			(0.5;0.7;1)	(0.08;0.12;0.26)	(0.6;0.4;1.2)
EO	(0.7;1;1)		(0.2;0.5;0.8)		(0;0;0.4)				(0.05;0.2;0.42)	(0.4;0.2;1.8)
NO		(0.5;0.7;1)	(0.5;0.7;1)	(0;0;0.3)	(0.4;1.2;5.3)	(0.2;0.5;0.8)	(0;0.2;0.3)		(0.61;0.32;0.35)	(1.6;0.8;1.4)
CCM			(0.5;0.7;1)		(0.7;1;1)			(0.2;1.8;2.5)	(0.08;0.22;0.13)	(0.2;0.4;1.1)
Relative Importance RIj	(0.3;1.1;2.11)	(0.7;1;2)	(0.7;1;3)	(0.7;1;4)	(0.7;1;5)	(0.7;1;6)	(0.1;1.2;2)	(0.7;1;8)		
Absulute Importance RIj*	(0.48;2.08; 4.02)	(0.04;0.2;0.15)	(2.2;2.4;4.22)	(0.4;0.8;1.2)	(0.7;2.5;2.4)	(0.36;1.24; 1.28)	(0.04;0.28; 2.21)	(0.36;1.24;1.3)		
Execution Cost Cj	(0.7;1;1)	(0.5;0.7,1)	(0.7;1;1)	(0.5;0.7;1)	(0.5;0.7;1)	(0.7;1;1)	(0.24;2.36;2.12)	(0.4;1.2;1.23)		
Marginal Profit Uj	(0.46;2.18; 4.26)	(0.04;1.21; 2.24)	(1.28;2.56 ;4.26)	(0.02;0.17; 0.34)	(0.12;1.28; 5.34)	(0;1.28;4.34)	(0;1.82;5.28)	(0.28;1.8;4.36)		
Deleted Fussy Value Df	2.27	1.375	2.665	0.175	2.005	1.725	2.23	2.06		
Target Value Di	3	1.01	2	2.5	5.28	1.2	1.2	3.6		

Calculating Value ◇
Target Value D_i Δ

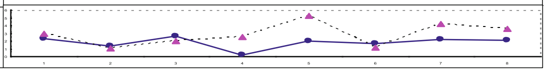


Fig. 100.1 Structure of HOQ of supply chain system

be order according to the comparison between index and target value from big to small as customer relationship management > demand forecasting > inventory control optimize > transportation decision-making optimization > JIT management. So supply chain system should also be optimized in accordance with this relationship.

At the same time, from the roof relationship matrix, four pairs of indicators are positively related. They are order optimization and customer management, information technology and warehouse site selection optimization, the optimization of inventory control and JIT management and customer relationship management and transportation decision optimization; and three pairs of indicators have negative correlation. They are information technology and demand forecasting method, customer relationship management and warehouse site selection optimization and information technology and transportation decision optimization. It means that during the process of supply chain system optimization, we can utilize the correlation reasonably. If one strategy which needs to be optimized has positive correlation with other strategies, one strategy method's improvement will bring up another strategy's improvement; on the contrary, if they have negative correlation, we cannot simply optimize a strategy but must have comprehensive evaluation to optimize. For example, customer relationship management is the index which has the farthest distance with target value the, so it need to be optimized first. When we carry out the optimization at the same time, it may bring the improvement of order optimization and transportation decision-making optimization. This optimization method can not only satisfy the requirement of enterprises' supply chain system optimization but also reduce cost.

100.4 Conclusion

According to an automotive industry supply chain system based on fuzzy QFD method, we can compare and analyze each performance parameter. Transforming customer demand to parameter requirements of supply chain system and applying fuzzy QFD principle in the supply chain system of automobile enterprise, we can analyze the importance and correlation of strategy methods and service factors. With the application of fuzzy house of quality (HOQ) method, we can get the analysis of system information and performance by comparing all the data. These works can provide a theoretical basis and practical experience for optimization supply chain system.

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Chapter 101
Analysis on a Competitive Cooperative Game of Electric Power Supply Chain

Xue-feng Ding and Qian Nan

Abstract At present the study on the competition and cooperation of the power supply chain focuses on the independent node enterprises rather than from the perspective of the whole supply chain. By taking the particularity of the electric power supply chain into account, combining the analysis of the conditions under the relationship among the coal suppliers and power producers, transmission providers, power distributors, customers and the members constitute as a game. Establishing a model in which three or more members in the supply chain participate and repeat the game. By analyzing the model, only through a highly dynamic adjustment, integrated and cooperative path, can an effective and competitive electric power market be set up. In this way, the power supply chain can have higher efficiency and produce more social welfare.

Keywords Competition and cooperation · Organizing mechanism · Repeated multi-party game · The electric power supply chain

101.1 Introduction

Since the 1990s, the supply chain management has become a main mode of the modern enterprises. The electric power supply chain management is further deepened with the particularity of the electric power supply chain on the basis of the supply chain management theory. It can be divided into the electricity coal the electric power equipment manufacturing, the power generating, transmission,

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distribution and electricity transaction. “Demand-pull” is the most significant feature. In the electric power supply chain, electricity coal suppliers producers, transmission providers, distributors are functional complementary and they need to form a dynamic functional network through contract. Every step must be effective and harmonious. The organization and coordination mechanism of the electric power supply chain is defined as establishing the adjustment mechanism and mode, the dynamic procedure At present, research on the competition and cooperation for supply chain management are mainly based on ideas, theories and methods of supply chain management combined with the actual operating characteristics of the power industry. For example, Dou et al. (2012) and Wang et al. (2008) pointed out the combined option price and quantity of the electricity supply chain dominated mainly by the electricity retailers are determined to realize optimal profit when the option pricing market changes. Xue et al. (2002) analyzed the market reformation in the power industry by employing supply chain theory. Suggesting that the electric network corporation should be the control center of the controllable type electric supply chain in the future. Qu et al. (2011) take the uncertainty of demand in the power supply chain into consideration and explain the importance of the coordination strategy of power supply chain. However, the game theory is considered as a good reflection of market competition essence so as to be applied into the study of the power market (Dak 2000), it is concerned by many scholars: Song et al. (2003) and Li and He (2007) combined with the Cournot and Bertrand models are constructed. The game behavior of the power plants is studied and the commercial efficiency of the power plants and the whole market under different strategies is discussed. Pan (2010) make use of a quantitative analysis was made about the duopoly model with bounded rationality. The results indicate that enterprises could adopt a strategy in the form of cooperative competition game to maximize their profits, and after a long time of gaming between the two sides the market would gradually stable a balanced state of equilibrium. Ma (Ma 2000; Wan 2008; Fan 2010) build an organization and coordination model of the supply chain through the study of the organization and coordination mechanism of supply chain, thus laying the foundation for the paper to establish a cooperative game model of power supply chain organization. (Trevor 2005; Sunil and Peter 1998; Zhou and Besant 2001; Quninn 2002) and others study and conclude these advantages of achieving Win–Win and the high efficiency of the whole supply chain. The most above scholars have a discussion by means of studying two related enterprises or each independent enterprise in power supply chain ignoring the long-term cooperation of each node enterprise. This paper is adapted for the new supply chain style after “the separation between the plant and the grid” reform. It regards each nodes enterprise as game problem and makes use of the repeated game theory further analysis in the node enterprises’ relationship in the power supply chain and refer to how to attain the optimum and high efficiency of the whole power supply chain which is under the condition of the multiple-stakeholder’s involvement.

101.2 Model

In this paper we assume that electricity suppliers, electric power plants, transmission and distribution providers to introduce market competition mechanism, consisting of groups to discuss whether the establishment of the electricity supply chain organization by contracts. If it is, every year is to discuss whether to maintain contract keep the existence of the organization of electric power supply chain. The discussion above are based on the organization and coordination mechanism of supply chain management. We will define the problem as a game model and make a detailed explain for it.

The first, we regard the economic agents as a whole, which exist in the electric power supply chain nodes with same properties and ignore the end user. For example, Multiple electric power companies are proceeding the production task of the electrical energy products at the same time. The game parties $n\ (2 = <n = <4)$ are composed of electricity coal suppliers, the electric power suppliers, transmission business and electric power distributors.

The second, each node member makes its decisions independently and simultaneously on the electric power supply chain organization problem that they can make a choice to join or not. $s_i \in \{1, 0\}$ implies the decision value of party i. While s_i is 1 implies to join, 0 implies not to join.

The third, each node enterprise decides simultaneously whether to join the supply chain and if any of them do not join, it does not affect the rest of members (not less than two game parties), that means the remaining parties can still choose to join. If just one party participate in the supply chain, the whole supply chain organization will be disconfirmed.

The fourth, payoffs of the each party can be indicated with each node enterprise's relative income that each node enterprise joins the organization of supply chain before and after with a sign standing for the parties ' payoffs of the supply chain. Further assumption that their own and other payoffs is known before and after joining the parties. All the above assumptions conform to the actual situation obviously. So it can be used a below formula to show the organization and coordination mechanism of the electric power supply chain.

For

$$G = \{s_1, \ldots, s_n; u_1, \ldots, u_n\}$$

$$u_i = Nc_N r_{iN} \tag{101.1}$$

$$N = \sum_{1}^{N} s_i \tag{101.2}$$

$$s_i \in \{1, 0\}, i = 1, 2, \ldots, n \tag{101.3}$$

Condition: N–n there were N parties choose to participate in the supply chain. It is called N node of supply chain. s_i indicates the strategies of game party.

r_{iN} indicates the contribution rate of i member in supply chain for N parties. $\sum_{i=1}^{N} r_{iN} = 1$ presents contribution rate of each party for the whole supply chain benefit. Contribution rate = Contribution amount/consumption. u_i indicates the payoff of the i party in the supply chain. $u_i < 1$ indicates the i party in the supply chains gets less payoffs than the non-participant time, which means i party is in a disadvantage in a N node of the supply chain payoffs distribution. If the i party does not participate the organization of supply chain, so $u_i = 1$, keep the status quo; If $u_i > 1$, which means i party is in a advantage in a N node of the supply chain payoffs distribution. At this time, the i party tend to actively involved in organization of the supply chain.

c_N indicates N node Value coefficient of electric power supply chain. c_N is the economic significance: In the electric power supply chain environment, it makes the whole supply chain's payoffs bring the multiplier benefits that the parties reach the common intention of human resources, financial factors and labor factors via coordination and cooperation. $u_i = Nc_N r_{iN}$ is payoff functions. According to the assumptions, That means the supply chain organizational members' own and other payoffs are known before and after joinning the parties.It can be defined payoffs functions for $u_i = Nc_N r_{iN}$.

From the above analysis, it can be learned that the electric power supply chain coordination mechanism can be described as a game model to be solved. For one-shot game, which means a n (limited) parties having limited of optional strategies of the complete static game model. In the electric power supply chain, as the members should maintain their long-term relationship. They must make sure the benefit at other stages so as to improve the benefit of the society as a whole. Although the process of repeated game is the repetition of the original game, the results of repeated game are not necessarily the simple repetition of the basic game. This paper establishes the limited repeated game model of the organization and coordination mechanism of the electric power supply chain on the basis of analyzing the electric power supply chain organization structure.

101.3 Model Analysis

101.3.1 One-Shot Static Game

As the specificity of electric power supply chain. In the whole electric power supply chain game process, the quantity of games ($2 \leq n \leq 4$) party is limited. Here we solve the n = 2, n = 3 with line method and then extend the conclusion.

When n = 2, the problem is the two sides game called the i and j. It could be random pair combinations among the electricity coal suppliers, the electric power plants, the transmission companies, and the distributors. The game Payoffs and strategies combinations can be showed as Matrix 101.1. Obviously there are two

Matrix 101.1

	j = 1	j = 0
i = 1	$2c_2r_{i2}, 2c_2r_{j2}$	1, 1
i = 0	1, 1	1, 1

statuses of the problem. The first, when $2c_2r_{i2} \geq 1$ and $2c_2r_{i2} \geq 1$ as Matrix 101.2 shows, the corresponding strategies combinations is that both parties participate in the supply chain or not. It means that the strategies combination of both sides are the best counter-measures for the other party's strategy.

The second, when $2c_2r_{i2} \geq 1$ and $2c_2r_{j2} \leq 1$, or $2c_2r_{i2} \leq 1$ and $2c_2r_{j2} \geq 1$, the game has two "Pure strategies Nash equilibrium". Typical Payoffs and strategies combinations such as Matrix 101.3 as shown.

If $c_N \geq 1$, $\sum_{i=1}^{N} r_{iN} = 1$, Therefore, $2c_2r_{i2} < 1$ and $2c_2r_{j2} < 1$ will not present.

When n = 3, The game Payoffs and strategies combinations can be shown as Matrix 101.4.

Obviously, according to different parameter, this game will have multiple "Nash equilibrium". As the c_N and r_{iN} Value change, a great many of "Pure strategy Nash equilibrium" will likely present with certain regularity. Therefore, the above game matrix analysis can draw the conclusion as below:

(1) The value changes of the Nash equilibrium synchronize with Value integration efficiency changes. When, $c_3 > c_2 > 1$, the strategy combinations of Payoffs inequation: $3c_3 > 2c_2 + 1 > 3$. The most efficient one is $\left(u_i, u_j, u_k\right) = \left(3c_3r_{i3}, 3c_3r_{j3}, 3c_3r_{k3}\right)$ The corresponding strategy combinations is (1,1,1), which 3 parties all chose to participate the electric power supply chain.But this strategy combinations has a certain condition,which become pure strategies Nash equilibrium solution. Hence $3c_3r_{i3} > 1$ has been established.

(2) When the value of c_N and r_{iN} are inappropriate, the problems may lead to two of three parties choose not to participate in the organization of electric power supply chain. Although the game has two pure strategies Nash equilibrium, the results of Payoffs are all to maintain the current situation.

(3) When the value of c_N and r_{iN} are inappropriate, it may present none of the three parties choose to participate in the organization of electric power supply chain l, the result of Payoffs is the same as the conclusion2.

(4) When the value of c_N and r_{iN} are inappropriate, it makes 3 parties all not join the organization of the electric power supply chain. But two of parties are easy to set up. The game Payoffs of the participants is more than the non-participants in the supply chain.

Matrix 101.2

	j = 1	j = 0
i = 1	$2c_2r_{i2}, 2c_2r_{j2}$	1, 1
i = 0	1, 1	1, 1

Matrix 101.3

	j = 1	j = 0
i = 1	$2c_2r_{i2}, 2c_2r_{j2}$	1, $\underline{1}$
i = 0	$\underline{1}$, 1	1, 1

Matrix 101.4

	j = 1	j = 0
K = 1	$3c_3r_{i3}, 3c_3r_{j3}, 3c_3r_{k3}$	$2c_2r_{i2}, 1, 2c_2r_{k2}$
i = 1		
i = 0	$1, 2c_2r_{j2}, 2c_2r_{k2},$	1, 1, 1
K = 0	$2c_2r_{i2}, 2c_2r_{j2}, 1$	1, 1, 1
i = 1		
i = 0	1, 1, 1	1, 1, 1

101.3.2 Description of the Repeated Multi-Party Game

The repeated multi-party game of the organization and coordination mechanism of the electric power supply chain is the limited repeated games that make the static game as a stage. For basic game is G, repetitions are T. Here is a discussion and solution about repeated game which includes two different cases: n = 2 and n = 3.

When n = 2, the repeated game stage solution is divided into two cases: The first case, the stage game has two pure strategy Nash equilibrium, so the stage game has several perfect Nash equilibrium paths of the sub game. The most efficient strategies combination is (1,1) that means both sides join the electric power supply chain. Finally $2c_2r_{i2}$ or $2c_2r_{j2}$ is the best average Payoffs of the each stage. The second case, the Stage game has only a Pure strategy Nash equilibrium, which has only a perfect Nash equilibrium path of the sub game, it means both sides do not join the electric power supply chain in any stage.

When n = 3, The stage games of the repeated game are also divided into two cases. The first case, the stage game has two or two more pure strategies Nash equilibrium. The second case, the Stage game has only a pure strategy Nash equilibrium, which has only a perfect Nash equilibrium path of the sub game that means all parties do not take part in the electric power supply chain in any stage.

The second case can be divided into three detailed cases: Case 1 is the most efficiency explanation of Pure Strategy Nash equilibrium. Three parties chose to participate in the electric power supply chain's strategy combination (1,1,1); Case 2 is the most efficiency explanation of pure strategy Nash equilibrium that any two of three parties construct the electric power supply chain. Such as (1,0,0), (0,0,1), (0,1,0). Case 3: Although the stage game has two pure strategy Nash equilibrium solutions, any two of three parties can't construct the electric power supply chain, so there doesn't exist the most efficiency strategy combination, such as (1,0,0), (0,0,1), (0,1,0). Under these three cases, the repeated game has multiple paths of "sub-game perfect equilibrium", the difference is that there might exist the different paths of the most efficiency of "sub-game perfect equilibrium".

101.4 The Practical Significance of Model

(1) The higher multiplier effect of the electric power dynamic supply chain. As the above model shows: In the dynamic electric power supply chain, all parties reach the common impact of human resources, financial factors, labor factors of the whole supply chain via coordination and cooperation so as to make the profit of participant is much higher than before. For example, the electric power purchasing of the provincial grid companies could convert into the electric power plant's income. The electric power company will use the income as for consumption or Electric power investment after deducting the savings which will be converted into the electricity coal suppliers' income. So the continuous recycle will lead the electric power supply chain income increasing in a multiple by the joint investments or expenses. The above example meets the electrical supply chain integration coefficient value c_N.

(2) The Dynamic adjustment of the electric power supply chain. One of the most important features of the supply chain management is the dynamic. That doesn't mean every organization of supply chain must exist for a long time, it's structure is not immutable after the establishment of the supply chain. The model can also be used to explain the characteristics and applications of the supply chain. The electric power supply chain relationship all depends on the value of r_{iN}. Only the parties' contribution rate in the Payoffs function obtained the appropriate value, the parties can reach the best pure strategy Nash equilibrium. The electric power supply chain structure can change by adjusting the value of r_{iN}.

(3) The Integration application in the electric power supply chain management. In the model, the c_N value is higher while the parties 's profits are higher as the contribution rate is fixed, it may also make the enterprise change from the disadvantage to the advantage and makes the impossible organizational cooperative relation available. At the same time the interests of all parties are improved. This point is very identical with the electric power supply chain management. On the one hand, the original high external cost (e g: the electric power equipment purchase charge) converts into a lower internal cost in a high integrated electric power supply chain. On the other hand, the integration improvement will strengthen the whole competitive advantage of the electric

power supply chain and then reach the dynamic optimum goal in the whole electric power supply chain.

(4) Cooperation is the guarantee of the organizational relationship of the electric power supply chain. The essence of the supply chain management is the relationship management which means all parties must abide by this relationship standard through certain mechanism specification. The essence of the supply chain management in model also reflects the repeated game's credit and commitment. A Limited pure strategies Nash equilibrium of the repeated game is the effective path which reaches the cooperative interests and improves the balanced efficiency. Long-term cooperation in all the participants must be eliminated the incredible threats and promises so as to keep the long-term cooperative relationship stable in the electric power supply chain. Such as: In the present electric power market, there is a long-term price cooperative game relation between the Electric power grid companies and the electric power stations: On one side, the electric power grid corporations are the public companies undertaking the great social responsibilities. On the other side, the electric power suppliers are independent enterprises that undertake their own profits and losses, it will be an inevitable trend by establishing and developing the long-term cooperative partnership or even the strategic alliance.

101.5 Conclusion

This paper has related each section's cooperative and integrated organizing mechanism establishment in the electric power supply chain as a game question, establishing a model in which three or more members in the supply chain participate and repeat the game. By analyzing the model, the research result shows that the complicated supply chain has the high efficiency and the dynamic adjustment. The application and operation of the integration in the supply chain management is a necessity for the organizational relationship of the electric power supply chain. Moreover, this paper also indicates competitive demand of each node enterprise and shows the direction for each node enterprises to participate in market competition.

However, this paper also has many limitations. It will be the future research direction about how to enhance competition efficiently and how to improve the production and operating efficiency in the whole electric power supply chain.

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Chapter 102
City Logistics Hierarchy of Jiangxi Province Based on Grey Clustering Model

Wei-hua Gan and Han Zhang

Abstract Modern logistics industry is the key industry during the 12th 5-year in Jiangxi province. How to plan systematically 11 cities' logistics industry in Jiangxi province is an important decision for the government. This paper mainly designs 5 quantitative index and 7 qualitative index, classifies all the 11 cities into three different logistics layer according to the census in Jiangxi province. Furthermore, this paper points out Nanchang, Jiujiang and Ganzhou should be the center logistics city, Yichun, Jingdezhen, Yingtan, Ji'an and Shangrao should be the key logistics city, Pingxiang, Fuzhou and Xinyu should be the developing logistics city based on grey clustering model. The aim is to utilize the logistics resources and realize regional logistics integration.

Keywords City logistics hierarchy · Grey clustering · Logistics hub city · Regional logistics system of Jiangxi province

102.1 Introduction

Regional logistics is a general description of logistics serving for locality and pass-by logistics in a specific area (Wang 2008). It is a macroscopic concept. At the same time, the regional logistics is the important part of regional economy, it is extremely important to develop the logistics industry to realize the economic high-efficiency growth. Regional logistics hub city is the core of the regional logistics

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system, which maintaining the connection with different economic area in order to organize the traditional independent transportation (waterway transport, highway transport, air transport and so on) to form a service system (Liu 2008). The level division of regional logistics hub city is the first job for regional logistics planning. The main purpose is dividing the level on the basis of the different types of logistics importance and macroscopic factors. There are many forms and requirements of regional logistics planning depending on the differences of logistics strength, functions and importance between different logistics nodes.

City logistics hierarchy of Jiangxi province should face the imbalance of the regional logistics development. On one hand, it should distinguish the primary and secondary regional planning and realize the logistics development level to formulate the cities for the regional logistics development and make them become the regional logistics development center. On the other hand, it should realize the common development of the regional logistics and promote the regional logistics integration.

102.2 Regional Logistics System Evaluation Index

In order to measure and evaluate the operation efficiency of regional logistics system, we should establish a general standard (Da Tong 2002). According to the collaborative development of regional logistics and regional economy, the regional logistics system evaluation index is established in Fig. 102.1. Evaluation index mainly reflects in four aspects: logistics demand, logistics supply, logistics effects and the environment of logistics development.

102.2.1 Regional Logistics Demand

(1) *Economic scale*. The index of Economic scale includes the Gross domestic product (GDP), sum of social retail consumer goods, Total social freights and so on. Logistics demand is the pie creatures of commodities demand. It is related with the consumer market and production market. Thus, the higher level of economy development, the more logistics spending, and the greater logistics demand.

(2) *Industrial structure and scale*. Each region making use of the resource superiority forms the industrial structure. The greater differences the industrial structure have, more frequently the complementary exchange of materials, then, the logistics demand is growing. Meanwhile competitive industries cluster have a huge pulling power for logistics demand and the number of competitive industries cluster is proportional to the pulling power of logistics.

(3) *Trade area*. Regional trade area decides the distance and link of goods transportation. It influences the selection and combination of transportation, circulation processing, handling, storage, packaging and so on. Generally speaking, the larger the regional trade area, the greater the logistics demand.

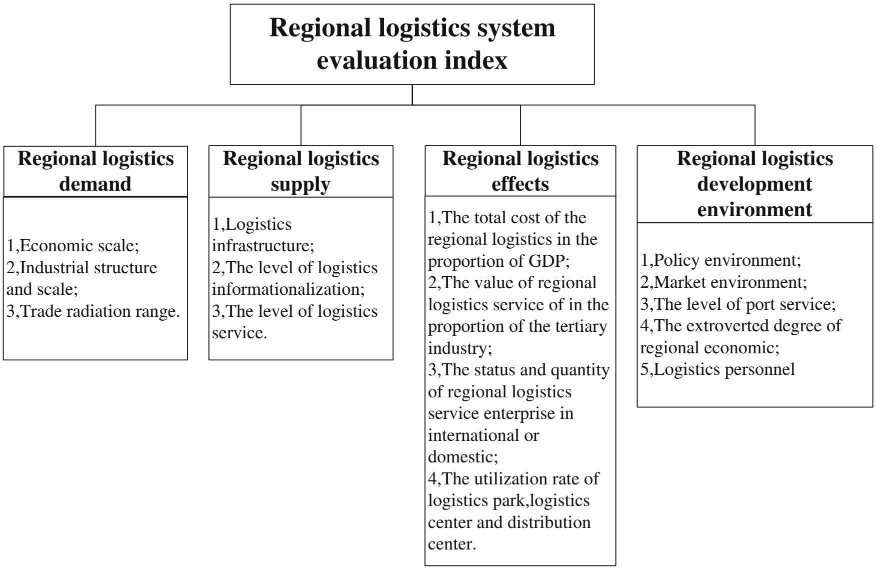

Fig. 102.1 Regional logistics system evaluation index

102.2.2 Regional Logistics Supply

(1) *Logistics infrastructure*. The index includes the layout and cooperation of various transportation modes, the transportation network, and the logistics facilities.

(2) *Logistics information level*. The index includes the regional logistics public information platform, the basic network transmission platform, etc. Higher the level of regional logistics information, greater the logistics supply.

(3) *Logistics service level*. The index includes the number of logistics parks, logistics centers, the third-party and the fourth-party logistics service enterprises, especially the level of service network technology, the satisfaction degree of customer demand and so on.

102.2.3 Regional Logistics Effects

Regional logistics effects can reflect the results of the regional logistics industry level, and contributes to find the problems of the regional logistics industry development. It mainly includes:

(a) The total cost of the regional logistics in the proportion of GDP.
(b) The value of regional logistics service of in the proportion of the tertiary industry.

(c) The status of regional logistics service enterprise in international or domestic trade.
(d) The utilization rate of logistics parks, logistics centers and distribution centers.

102.2.4 Regional Logistics Development Environment

Regional logistics development environment mainly refers to the external factors of the regional logistics development, including the policy environment, market environment, port service level, the outgoing degree of regional economy, the logistics personnel and so on.

(1) *Policy environment*. Modern logistics industry is the indispensable important component of social reproduction. Therefore, regulations and policies are certainly the component of regional logistics planning.

(2) *Market environment*. good market environment can accommodate the regional logistics development. It is said the goods business is the pilot of logistics, more advanced the goods business, higher the logistics level.

(3) *The level of port service*. The main solution to improve the ports service level is to raise the customs clearance efficiency of all the relevant departments. It is not only to deepen the reform of the customs, but also to coordinate all the related departments. Furthermore, to prompt the modern electronic data interchange technology (EDI).

(4) *The extroverted degree of regional economy*. Regional economy extroverted degree includes the regional urban economic function, the international reputation of the ports and airports. Among them, regional urban economic function accounts for the most logistics volume, such as the exhibition center, trade center, futures trading market, financial service. The higher international publicity the ports and airports are, the more attractive of the shipping companies, airlines, railway and highway transportation companies are.

(5) *Logistics personnel*. The construction of regional logistics system needs a large number of high quality professional talents that known as the modern logistics management and operation. Thus, the training and introduction of logistics personnel is an important measure.

102.3 City Logistics Hierarchy of Jiangxi Province Based on Grey Clustering Model

Considering the particularity of the logistics industry, city logistics hierarchy should both analyze the level of regional social economic development, industrial layout, inter-modal transportation and consider the industry contact and transport links between each cities.

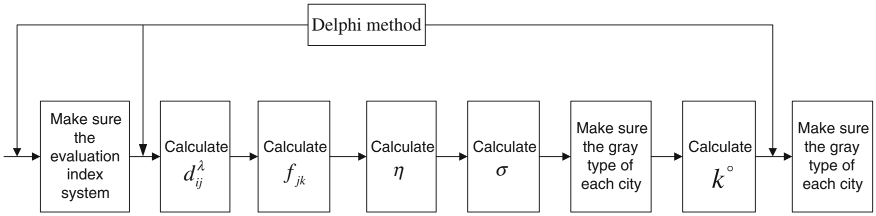

Fig. 102.2 The process of deciding logistics hub city

Grey clustering is a kind of method that judging and inducing the clustering object by the defined gray type for the albino number of different clustering index Peng and Yuanhe (2011). This paper puts forward the mentality of logistics hub city determination through Delphi method shown as Fig. 102.2.

Define the symbol:

$I = \{1, 2, \ldots, w\}$, $i \in I$: the collection of regional cities;
$J = \{1, 2, \ldots, m\}$, $j \in J$: the collection of evaluation index;
$K = \{1, 2, 3\}$, $k \in K$: the grey type of city logistics development;
$K = 1$: important;
$K = 2$: general;
$K = 3$: minor;
$\eta = (\eta_{jk})$: converted coefficient matrix,
η_{jk}: the converted coefficient that the j kind of index for the k gray type;
$\sigma = (\sigma_{ik})$: clustering coefficient matrix,
σ_{ik}: the clustering coefficient, that the i kind of cities for the k gray type;
d_{ij}^{λ}: the whitened-value that the i kind of cities for the k index;
d_{ij}: the code of d_{ij}^{λ};
$f_{jk}(d_{ij})$: the albino function that the j index for the k gray type;
k°: the gray type of city i.

102.3.1 Determine the Evaluation Index System of Logistics Hub City in Jiangxi Province

Depending on statistical data of Jiangxi province, confirm the main factors influencing the classification of the logistics hub cities by combined with four indicators of regional logistics system of Jiangxi province (logistics demand, logistics supply, logistics effect and logistics development environment). The evaluation index system is shown in Fig. 102.3.

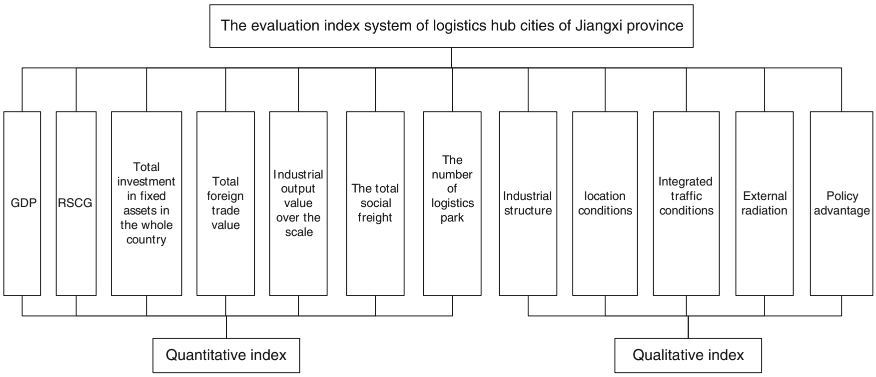

Fig. 102.3 Evaluation index of logistics hub cities in jiangxi province

102.3.2 Standardization of Each Index

According to the evaluation index system, based on *Jiangxi statistical yearbook 2011* and the statistical bulletin of each city in Jiangxi province, quantitative evaluation indexes can be achieved.

Then determine the value of each qualitative index and define as five level: very good, good, generally, bad, very poor, valued for 5, 4, 3, 2, 1 respectively. Combined the qualitative and quantitative evaluation indexes, confirmed the indexes of the logistics hub city of 11 cities in Jiangxi province, as is shown in Table 102.1.

Table 102.1 The grey clustering evaluation results of city logistics hierarchy of Jiangxi province

	City	Results analysis		
		σ_{ik}	Grey type	Results
1	Nanchang	0.837	1	The center logistics city
2	Jingde zhen	0.666	2	The key logistics city
3	Pingxiang	0.822	3	The developing logistics city
4	Jiujiang	0.755	1	The center logistics city
5	Xinyu	0.727	3	The developing logistics city
6	Yingtan	0.602	2	The key logistics city
7	Ganzhou	0.689	1	The center logistics city
8	Ji'an	0.650	2	The key logistics city
9	Yichun	0.817	2	The key logistics city
10	Fuzhou	0.773	3	The developing logistics city
11	Shangrao	0.650	2	The key logistics city

For the benefit-type index:

$$d_{ij} = \frac{d_{ij}^{l}}{\max\limits_{i \in I} d_{ij}^{l}}$$

For the cost-type index:

$$d_{ij} = \frac{\min\limits_{i \in I} d_{ij}^{l}}{\underset{i \in I}{d_{ij}^{l}}}$$

After data processing get the matrix:

$$d_{ij} = \begin{bmatrix} 1.00 & 1.00 & 0.08 & 1.00 & 0.37 & 0.84 & 1.00 & 0.50 & 0.40 & 0.40 & 0.40 & 0.40 \\ 0.21 & 0.19 & 0.35 & 0.15 & 0.09 & 0.12 & 0.00 & 0.67 & 1.00 & 0.67 & 0.50 & 0.67 \\ 0.24 & 0.21 & 0.23 & 0.09 & 0.14 & 0.56 & 0.11 & 0.67 & 0.67 & 1.00 & 1.00 & 1.00 \\ 0.47 & 0.38 & 0.17 & 0.34 & 0.20 & 0.65 & 0.11 & 0.67 & 0.40 & 0.40 & 0.50 & 0.50 \\ 0.29 & 0.15 & 0.23 & 0.68 & 0.16 & 0.62 & 0.22 & 0.67 & 1.00 & 1.00 & 1.00 & 1.00 \\ 0.16 & 0.11 & 0.63 & 0.75 & 0.16 & 0.33 & 0.00 & 1.00 & 0.67 & 0.67 & 0.50 & 0.50 \\ 0.51 & 0.50 & 0.20 & 0.31 & 0.17 & 1.00 & 0.22 & 0.67 & 0.50 & 0.50 & 0.40 & 0.50 \\ 0.33 & 0.27 & 0.00 & 0.21 & 0.15 & 0.45 & 0.00 & 1.00 & 0.50 & 0.67 & 0.67 & 0.67 \\ 0.39 & 0.35 & 0.25 & 0.12 & 0.17 & 0.73 & 0.11 & 0.67 & 0.67 & 0.50 & 0.67 & 0.50 \\ 0.29 & 0.31 & 0.19 & 0.11 & 1.00 & 0.51 & 0.00 & 1.00 & 1.00 & 1.00 & 1.00 & 1.00 \\ 0.41 & 0.44 & 1.00 & 0.31 & 0.16 & 0.99 & 0.33 & 1.00 & 0.50 & 0.50 & 0.67 & 0.67 \end{bmatrix}$$

$f_{jk}(d_{ij})$ is shown as Fig. 102.4.

$$f_{j1}(d_{ij}) = \begin{cases} \frac{1}{c_{j1}} d_{ij} & d_{ij} \in [0, c_{j1}] \\ 1 & d_{ij} \in [c_{j1}, +\infty] \end{cases}$$

$$f_{j2}(d_{ij}) = \begin{cases} \frac{1}{c_{j2}} d_{ij} & d_{ij} \in [0, c_{j2}] \\ -\frac{1}{c_{j2}} d_{ij} + 2 & d_{ij} \in [c_{j2}, 2c_{j3}] \end{cases}$$

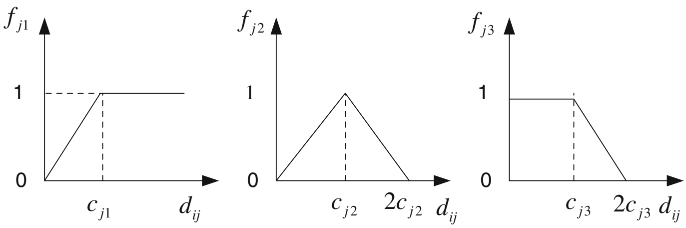

Fig. 102.4 Different gray type

$$f_{j3}\left(d_{ij}\right) = \begin{cases} 1 & d_{ij} \in \left[0, c_{j3}\right] \\ -\frac{1}{c_{j3}} d_{ij} + 2 & d_{ij} \in \left[c_{j3}, 2c_{j3}\right] \end{cases}$$

$$c_{j1} = \max_{i \in i} d_{ij},\ c_{j2} = \frac{1}{w} \sum_{i=1}^{w} d_{ij},\ c_{j3} = \min_{i \in I} d_{ij}\,.$$

After calculation:

$$c_{jk} = \begin{bmatrix} 1.00 & 0.39 & 0.16 \\ 1.00 & 0.36 & 0.11 \\ 1.00 & 0.30 & 0.00 \\ 1.00 & 0.37 & 0.09 \\ 1.00 & 0.25 & 0.09 \\ 1.00 & 0.62 & 0.12 \\ 1.00 & 0.19 & 0.00 \\ 1.00 & 0.77 & 0.50 \\ 1.00 & 0.74 & 0.40 \\ 1.00 & 0.66 & 0.40 \\ 1.00 & 0.66 & 0.40 \\ 1.00 & 0.67 & 0.40 \end{bmatrix}. \quad j = 1, 2\ldots, 12; k = 1, 2, 3$$

102.3.3 Confirm the Convert Coefficient Matrix

$$\eta_{jk} = c_{jk} / \sum_{j=1}^{m} c_{jk}$$
$$k = 1, 2, 3;\ j = 1, 2, \ldots, m$$

After calculation

$$\eta = \begin{bmatrix} 1/12 & 0.0649 & 0.0585 \\ 1/12 & 0.0593 & 0.0428 \\ 1/12 & 0.0507 & 0.0001 \\ 1/12 & 0.0618 & 0.0320 \\ 1/12 & 0.0421 & 0.0348 \\ 1/12 & 0.1032 & 0.0452 \\ 1/12 & 0.0321 & 0 \\ 1/12 & 0.1291 & 0.1873 \\ 1/12 & 0.1228 & 0.1498 \\ 1/12 & 0.1108 & 0.1498 \\ 1/12 & 0.1108 & 0.1498 \\ 1/12 & 0.1124 & 0.1498 \end{bmatrix}$$

Table 102.2 The indexes d_{ij}^{l} of logistics hub city of 11 cities in Jiangxi province

City	GDP (Yi yuan)	RSCG (Yi yuan)	Total investment in fixed assets in the whole country (Yi yuan)	Total foreign trade value (Million)	Industrial output value over the scale (Yi yuan)	The total social freight (Mtpa)	Industrial structure	Location conditions	Integrated traffic conditions	External radiation	Policy advantage
Nanchang	2207.11	756.41	1923.35	530657	2765.50	12365.39	4	5	5	5	5
Jingde zhen	461.50	141.65	439.47	80914	685.62	1783.05	3	2	3	4	3
Pingxiang	520.39	159.06	663.69	45342	1013.02	8280.18	3	3	2	2	2
Jiujiang	1032.06	286.69	877.39	181505	1476.55	9603	3	5	5	4	4
Xinyu	631.22	112.74	658.31	360828	1188.50	9096	3	2	2	2	2
Yingtan	344.89	86.4	241.97	396328	1164.90	4926.55	2	3	3	4	4
Ganzhou	1119.74	375.35	764.86	163000	1267.89	14767.60	3	4	4	5	4
Ji'an	720.53	202.83	643.61	112928	1132.94	6649.93	2	4	3	3	3
Yichun	870.00	267.86	613.40	65990	1230.50	10755.7	3	3	4	3	4
Fuzhou	630.01	236.68	805.21	55856	7387.78	7531	2	2	2	2	2
Shangrao	901.00	330.10	153.10	166658	1171.42	14580.6	2	4	4	3	3

(a) *Confirm the clustering coefficient matrix* $\sigma = \sigma(\sigma_{ik})$:

$$\sigma_{ik} = \sum_{j=1}^{m} f_{jk}(d_{ij})\eta_{jk}$$
$$i = 1, 2, \ldots, w;\ k = 1, 2, 3$$

According to the calculation formula:

$$\sigma = \begin{bmatrix} 0.837 & 0.479 & 0.136 \\ 0.384 & 0.666 & 0.273 \\ 0.492 & 0.652 & 0.822 \\ 0.755 & 0.532 & 0.247 \\ 0.584 & 0.635 & 0.727 \\ 0.477 & 0.602 & 0.551 \\ 0.689 & 0.427 & 0.033 \\ 0.424 & 0.650 & 0.093 \\ 0.422 & 0.817 & 0.121 \\ 0.373 & 0.488 & 0.773 \\ 0.581 & 0.650 & 0.483 \end{bmatrix}$$

(b) *After calculation, gray clustering evaluation results is shown in* Table 102.2:

102.3.4 Grey Clustering Evaluation Results

According to the grey clustering evaluation results, Nanchang, Jiujiang and Ganzhou should be the center logistics city; Yichun, Jingdezhen, Yingtan, Ji'an and Shangrao should be the key logistics city; Pingxiang, Fuzhou and Xinyu should be the developing logistics city.

102.4 Conclusion

This paper classifies the various levels for 11 cities in Jiangxi province by the grey clustering method. 12 indexs are established to reflect the city logistics hierarchy of Jiangxi province. It contributes to the planning of logistics hub city in Jiangxi province and makes these cities to be the important node of logistics system, the aim is to realize regional logistics integration and develop logistics industry effectively.

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Chapter 103
Construction Project Procurement Method Based on the Theory of Lean Construction

Zhi Sun and Shou-jian Zhang

Abstract Based on the analysis of the current procurement situation in construction industry of China, this paper reviewed the research achievement on construction project procurement management in recent years; analyzed the deficiencies in procurement management based on the characteristics of construction project, and elaborated on the problems existing in procurement processes from two aspects of procurement behaviors and the whole procurement system. Based on the advantages of procurement outsourcing and lean supply in lean construction theory, this paper analyzed the possibility of construction project procurement outsourcing, categorized the items to be procured and proposed the operational mode for the cooperation between customer and supplier. In the last section, we proposed the safeguard measures for construction project procurement outsourcing cooperation.

Keywords Lean construction · Procurement outsourcing · Procurement outsourcing facilitator · Purchasing system · Purchasing cost

103.1 Introduction

In recent years, material purchasing which occupies the highest construction cost has become the core problem of construction project cost management. Based on precious research results, the materials procurement cost accounts to about 50–60 % of the whole project cost (Hadikusumo et al. 2005). So as the effective measure of controlling the project cost, procurement management plays a very

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important role in construction project management. While the procurement management in China's construction industry remains a very low level, many mature procurement methods in the manufacturing industry cannot be well applied to the construction projects due to their unique characteristics, such as the complicated construction process with many participants, the complex interface management, the long production cycle and the uniqueness of construction site.

The domestic and foreign scholars have done a lot of meaningful exploration in the field of procurement management and procurement models which is directed to the characteristics of construction project management. The supply chain can enhance the core competitiveness of construction enterprises, improve the building performance, supply advanced applicable and effective way to face the challenges of the economic globalization (Wang and Xue 2006). The advantages of centralized bidding and purchasing were under discussion by principal-agent theory. Centralized procurement becomes an effective model for reducing the purchasing costs, because of its characteristics, such as the large-scale of procurement, multitudinous number of the bidders and the efficacious supervise system (Zhang 2008a). The virtual procurement centre was founded in the mode of EPC, and the procurement management method was optimized for the lever materials and the strategic materials (Zhang 2008b). The project materials can be divided into four species, and manage these four types respectively can reduce procurement costs (Li and Zhang 2005). The core of the lean construction idea is using less manpower, equipment, time and the space to create as much value as possible, it can also more and more approach the users, provide the product which they want truly.

Lean construction procurement means selecting the "qualified" suppliers at the "requested" time to purchase the "right batch" of "right" products with the "right" price. The study of procurement mode based on the idea of lean construction is the effective way to achieve lean procurement in construction industry.

Procurement outsourcing derived from the manufacturing industry, which aims at concentrating the manpower and other resources of an enterprise on its businesses with core competitive advantages. Considering the characteristics of the construction projects, this paper categorized the materials needs to be procured in a general project, discussed the possibility of applying procurement outsourcing in the construction industry, and proposed a brand new procurement mode for construction projects to meet the lean requirements of construction project procurement (Thomas and Griffin 1996; Ni et al. 2012; Yu et al. 2012; Chen and Sarker 2010).

103.2 Analysis of the Construction Project Procurement Problem

The procurement of construction project is an activity to meet the needs of production process of construction and an important link between the demander and the supplier. It is necessary to discuss the problems of the procurement of construction, because of it is easy to become the bottleneck of the cost management.

103.2.1 The Impact of Construction Characteristics on the Procurement Behavior

There are some similarities between construction procurement and traditional manufacturing industry procurement, but there are still some differences between them. In view of the demanders they will take extra effort to deal with the procurement process and the cost of stock. In view of the suppliers they should pay attention to the cost of transaction which is caused by the homogeneous competition.

(1) *The non-repeatability of the construction process*
On one hand, each project procurement has a one-time feature, and the objects of procurement are different during each purchase. On the other hand, the relationship of construction industry procurement exists only between the supplier and the single project, each transfer of the ownership of property means the end of a supply–demand relation, so it's hard to learn the knowledge from the deal, and therefore there are lots of risks in this situation.
(2) *The limitations of the construction activity*
The materials used in the construction process always need to be transported to the construction site, but the conditions of the storage are limited at the site, the cost of storage is not low, and it is possible to cause the cost by repeat transportations (Xuefeng 2007).
(3) *The uncertainty of the construction site*
There are many uncertainties at the construction site because of the long construction period and the outside construction. So the materials supply should accordingly be adjusted to meet the change. The change of the procurement plan may cause the complex interface problem, because the supply chain needs the corporation of many enterprises. The supply chain is easy to lose the stabilization, so it is necessary to manage the change of procurement.

103.2.2 The Uncertainty of the Construction Procurement System

As the two main parts of the procurement activity, the supplier and the demander both want to reduce the cost of procurement and improve the efficiency. But the unsteadiness of the whole supply chain procurement activity will cause the system of construction procurement hard to achieve the ideal state. The following section will discuss the unsteadiness of the system.

The uncertain factors which are caused by the procurement between the supplier and demander are mainly from four areas: the supply of construction materials, the construction process, the logistics process and the deviation of demand information.

(1) *The uncertainty of the construction materials supply*
The demander cannot get materials on time, because of the variety of construction materials, large quantities, variation of construction site (projects usually locate in different cities), and the lack of local familiar suppliers. Many factors may delay the supply of goods.
(2) *The uncertainty of construction process*
The construction process may be suspended by adverse weather condition, and the carelessness of the workers may also cause the shutdown. Finally these behaviors affect the whole procurement activity. On the contrary, the procurement behavior also affects the construction process, such as the goods were sent to the wrong places, the unanticipated adverse geological conditions, and the dispute of interface problem. All these will cause the system of procurement to lose the stability.
(3) *The uncertainty of logistics distribution process*
Logistics distribution means sending the specified number of materials to the designated locations with the minimum cost in the specified period of time (Xuefeng 2007). The logistics distribution easily affects the whole procurement process due to the limit of time and space. The uncertainty of the materials distribution affects the whole construction process.
(4) *The deviation of demand information*
Construction project involves great variety of materials, and the supply chain is relatively complex and changeable. The information of supply chain lacks fidelity easily due to the complex spread link. Moreover such as the materials for decorate are flexible, the variability in customer preference causes irregular purchase intent. The uncertainty of the demand information and the inaccurate prediction of the market will cause the system to lose the stability.

103.3 The Outsourcing Procurement Management Method

The outsourcing procurement management method is one of a way to deal with the materials supply problem of construction project. The outsourcing method can not only result in less procurement cost, but also can bring higher efficiency of procurement and the professional services. This method can improve the efficiency of procurement, and reduce the cost of project.

103.3.1 Based on the Idea of Lean Construction to Determine the Scope of the Outsourcing Procurement

The basic goal of lean construction is using the perfect construction process to provide users with the value product. The traditional procurement lacks the targeted planning, so the new method need rational division of the procurement objects.

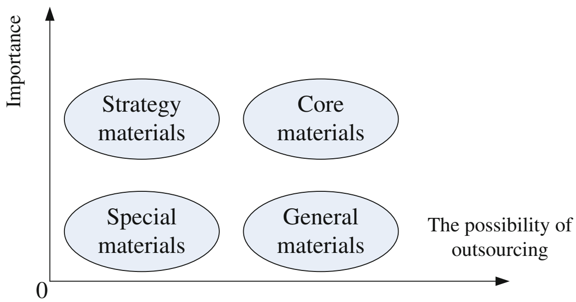
Construction project needs to purchase a wide variety of materials. The plan of procurement is made according to the materials significance and the ability of market supplies. In recent years more and more enterprises begin to use the mixed procurement strategy. The procurement department of the enterprise centralized the purchase part of their materials, and each project decentralized the purchase the other part of the materials. Similarly, procurement outsourcing management model does not apply to the procurement of all materials, it is reasonably necessary to divide procurement outsourcing division of the object.

Classify the materials mainly based on two factors: one of them is the value of the goods to company, the other one is the risk of supplement which means the short-term and long-term security of supply capacity, number of suppliers, and the competitive level of supplement (Liu 2001). Based on the different importance levels of the materials and the possibility of the outsourcing, we divide the construction materials into four types in Fig. 103.1: strategic materials, special materials, core materials and general materials.

Strategic materials—The suppliers of this type are relatively stable, leading time of purchase is relatively long, and these materials have high value. These materials are mainly large-scale equipment for construction. Such as machinery equipment for production, voltage transformer, switch cabinet, air-conditioning, system for fire alarm, etc. this type requires a higher quality of goods, and the brand loyalty is also very high. The enterprises buy these type materials centrally. This type isn't suitable for outsourcing procurement strategy because of the small batches of purchase.

Core materials—the market characteristic of this type is buyer's market, the time characteristic is advanced purchase, time for the selection of suppliers is usually rich, value is characterized by their larger amounts and the maximum total cost of materials. Such as steels, cement, wood, plumbing pipes, construction ceramics, sanitary ceramics, glass and its products, decoration materials, internal and external wall and floor tiles, etc. This type is suitable for outsourcing procurement strategy because of the high demand and the high brand loyalty. This type is suitable for outsourcing procurement strategy.

Fig. 103.1 The classification of procurement materials



Special materials—the market characteristic of this type is seller's market, the time characteristic is not relax. Relatively small value characteristics with small demand. The special materials include some new building materials and some special materials that are less used in building construction. Such as wall materials, decorative materials, doors and windows materials, insulation materials, waterproofing materials, bonding and sealing materials, etc. Such material has a lightweight, high strength, insulation, energy-saving, saving soil, decorative and other excellent properties. So costs are higher, demand is limited, do not have the scale effect. This type is not suitable for outsourcing services, the project can entrust a professional team of the construction for the procurement.

General materials—the market characteristic of this type is buyer's market, and this type has stable price, used in construction of foundation, structure and decoration.

103.3.2 The Operation Mode of Outsourcing Procurement Method

The demander can purchase the materials which are suitable for outsourcing by the third-party procurement service providers after reasonably classifying the materials. Figure 103.2 points out the traditional procurement flow of the procurement process of the whole supply chain. In this figure the demanders have to put their energy into the selection of qualified suppliers, and there is a lot of work to do, such as supplier identification, supplier selection, estimate procurement risk, calculate cost savings, material samples, negotiate with suppliers and the signing of procurement contracts. After these steps the demander should deal with the onsite storage of construction materials.

The first step of implementing the outsourcing procurement strategy is to choose the mature third-party procurement service providers. The providers are in charge of the whole process of the procurement and integrate the individual small suppliers at the request of demander. This model uses the purchase scale to reduce the procurement cost, and create the value for the client, finally forms the benign

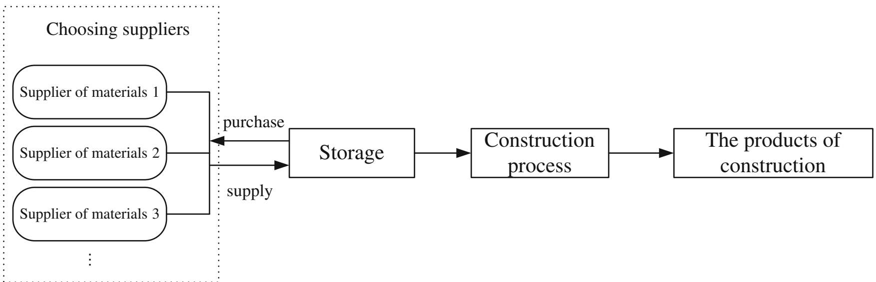


Fig. 103.2 The flow chart of traditional procurement

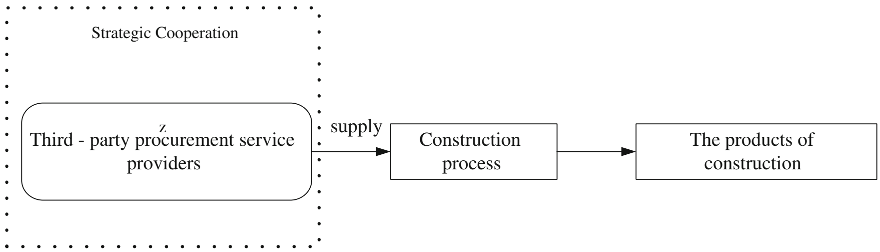


Fig. 103.3 The flow chart of outsourcing procurement

circulation of the cooperation. Figure 103.3 points out the process of the outsourcing procurement. The demander can save lots of management resources by this type.

The core problem of construction project procurement is to find the mature third-party procurement service providers, and try to establish the strategic partnership with them. This type reduces the cost of procurement by the service providers integrating the procurement resources and the scale of the whole supply chain.

The technical specifications of the supplies should be requested by construction enterprise firstly, and the demander examines and verifies the technical indicators of materials. The department of engineering confirms the delivery time, in order to ensure the materials arrive at the project site at the right time. Finally the financial department settles with the supplier. In this model the project site should submit the materials requirements planning to parent company. Parent company buys the materials through the outsourcing procurement services providers. The various materials selection and management will be done by the service providers throughout the process. These small suppliers could be from everywhere. The integration ability of the service providers forms the scale in order to reduce the cost, and finally forms the virtuous cycle of cooperation.

The core provider of the outsourcing method can satisfy the materials requirement of the parent company and the project site, the procurement based on lean construction thinking is the "pull" style. This mode declines the coordination links because of the cooperation with the core provider. At last the materials can be provided at the "demand" time, using the "right" price, to provide the "right batch" and the "quality" product.

103.4 The Comparison Between Traditional Procurement and the Method of Outsourcing Procurement

Excluding the impact of prices on the purchasing costs, only to consider the influence of purchasing frequencies, we compared the procurement outsourcing based on lean construction theory to the traditional procurement.

103.4.1 A Single Product Purchasing Model Under the Traditional Procurement

First, give the basic elements of the procurement issues, including:

(1) Demand rate: demand of per unit time for certain items. Indicated by variable D;
(2) Order quantity: each purchase includes the number of materials. Indicated by Q.

Set the following assumptions before establishing the traditional procurement model:

(1) Demand is continuous and uniform, the demand rate D is known as constant, after receiving a number of items, temporary storage in warehouses, and will be consumed with rate D (pieces/year);
(2) Replenishment can be done transiently, meaning additional time is approximately zero;
(3) Not allowed out of stock, it does not take into the shortage cost.

This storage model can be described by the Fig. 103.4. In the figure the storage rose from zero to Q immediately when the materials arrive, and then consumed with the rate of D when the storage descend to zero immediately added that the inventory once again to return to Q.

Set the model variables:

(1) Cc: The unit cost of materials
(2) Cf: Fix cost per order;
(3) Cs: The storage cost per unit time of each material;
(4) TOC: Cost of bulk orders for materials of each year;
(5) TSC: Annual storage cost.

Each order quantity is Q, order number must meet the annual demand, and so the number of annual subscription is:

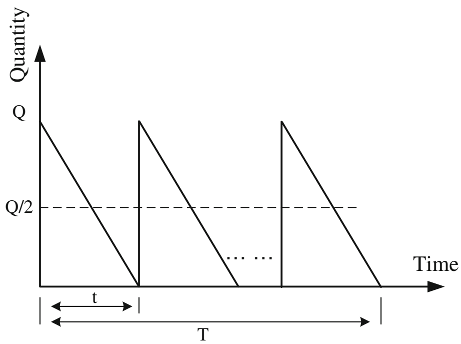


Fig. 103.4 The storage model

$$n = D/Q \tag{103.1}$$

As the ordering costs (TOC) is generated for each order, so we can derive the cost of annual order:

$$TOC = C_f(D/Q) \tag{103.2}$$

Each order quantity is Q, then the average storage is Q/2, therefore, the annual storage cost is:

$$TSC = (Q/2)C_S \tag{103.3}$$

The sum of ordering costs and storage costs is the total cost of ordering (TC)

$$TC = TOC + TSC = C_f(D/Q) + (Q/2)C_S \tag{104.4}$$

Objective of the study is to minimize the total cost TC, from the TC expression can be seen that TC is a function of Q, the derivative of TC to Q, and make it equal to zero:

$$\frac{dTC}{dQ} = -\frac{C_f D}{Q^2} + \frac{1}{2}C_S = 0 \tag{103.5}$$

So

$$Q^* = \sqrt{\frac{2C_D D}{C_S}} \tag{103.6}$$

And the Q* from the Eq. (103.6) minimizes the TC, because: $\frac{d^2TC}{dQ^2} = \frac{C_f D}{Q^3} > 0$ The optimum annual order number is n*:

$$n^* = \frac{D}{Q^*} = \sqrt{\frac{DC_S}{C_f}} \tag{103.7}$$

The minimum of TC is obtained:

$$TC_{\min} = C_f(D/Q^*) + (Q^*/2)C_s \tag{103.8}$$

103.4.2 Model Under the Outsourcing Procurement Method

Traditional decentralized procurement model needs each supplier individually supply, the cost of procurement is high. The outsourcing procurement method based on lean construction idea can provide most of materials in one procurement behavior, so the cost can be controlled. In practice, the less demand for products in each order also needs to pay the corresponding additional cost. According to the characteristic of outsourcing procurement, the low frequency orders can be ordered with the high frequency orders in this model. Achieved the purpose of centralized procurement cost savings

First of all, set the variables:

(1) The number of items: i(i = 1,2, …, m);
(2) Di: The annual demand for item i;
(3) Csi: The storage cost of each item i in unit time;
(4) CD: The fixed costs of each order, the type and the batch of the materials have nothing to do with the cost;
(5) CDi: Additional ordering cost of material i.

To determine the most frequently ordered items. Suppose each product is ordered, this time fixed cost CD to be apportioned to each item, and with the formula (103.7) can be calculated for each item of the annual subscription number, and find the maximum:

$$n_{\max} = \max\left(\sqrt{\frac{\mathrm{D_i C_{si}}}{2(\mathrm{C_D} + \mathrm{C_{Di}})}}\right)(i = 1, 2, \ldots, \mathrm{m}) \tag{103.9}$$

Identify the number of other items ordered with the most frequently ordered items. That means calculating the number of annual subscription for each item, and then calculating the multiples. The most frequently materials must be ordered every time, so the fixed cost of the other goods apportion to such materials. The cost of the other materials *i* is only the additional cost. Similarly using formula (103.7) can calculate the optimum annual order number:

$$n_i = \frac{\mathrm{D}}{\mathrm{Q}^*} = \sqrt{\frac{\mathrm{D_i C_{si}}}{2\mathrm{C_{Di}}}}(i = 1, 2, \ldots, \mathrm{m}) \tag{103.10}$$

Calculate the multiples of number of material *i* orders and the number of the most frequent material orders:

$$\mathrm{e_i} = \left[\frac{\mathrm{n_{max}}}{\mathrm{n_i}}\right](i = 1, 2, \ldots, \mathrm{m})\,(\text{``[]'' is the rounding symbol}) \tag{103.11}$$

After determine the frequency of each item order, recalculate the number of the most frequent material orders. When we calculate the n_i in the first model, the fixed cost of each order is Cf = CD + CDi, the material i is the most frequent material. However the most frequent material need to be ordered every time, and the other materials are ordered n_i time. So the material i additional cost of the actual order is CDi/ei. The effective order costs of each order should be:

$$\mathrm{C_D} + \sum_{i}^{\mathrm{m}} \frac{C_{Di}}{e_i}(i = 1, 2 \ldots, m) \tag{103.12}$$

Reference to Eq. (103.7) obtains:

$$n = \sqrt{\frac{\sum_{i=1}^{m} \mathrm{D}_i \mathrm{C}_{\mathrm{si}}}{2\left(C_D + \sum_{i=1}^{m} \frac{C_{Di}}{e_i}\right)}} \quad (103.13)$$

Calculate the revised frequency for each material $n_i = n/e_i$, and then calculate the order batch $Q_i^* = D_i/n_i$.

Annual cost of bulk orders:

$$TOC = C_D{}^* n + \sum_{i=1}^{m} D_{Di}{}^* n_i \quad (103.14)$$

Annual cost of storage:

$$TSC = \frac{Q^*}{2} C_S \quad (103.15)$$

The minimum total cost of outsourcing procurement model:

$$TC_{\min} = TOC + TSC = C_D^* n + \sum_{i=1}^{m} C_{Di}^* n_i + \frac{Q^*}{2} C_s \quad (103.16)$$

103.5 Conclusions

By analyzing the studies carried out by other scholars on construction project procurement management, coupled with the mature purchase outsourcing mode adopted in supply chain management of the manufacturing industry, this paper proposed the procurement outsourcing mode for the construction project. The paper firstly analyzed the problems existing in the procurement processes from the aspect of procurement behavior and the stableness of procurement system. We concluded that complicated construction processes will increase the cost of procurement, and the self-managed procurement distracts too much of the enterprise's energy. Based on the idea of lean construction, we analyzed the advantages of construction procurement outsourcing, categorized the items to be procured, elaborated on the items suitable for procurement outsourcing and proposed the operation mode of procurement outsourcing. By comparing the traditional procurement with the proposed procurement outsourcing, we analyzed the value of outsourcing under the idea of lean construction.

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Chapter 104
Design of Lean Supply Chain for Real Estate Operations

Hong-xian Yuan and Xue-qing Wang

Abstract The use of advanced information management system to achieve integrated management of real estate enterprises has been one of the most significant elements to be resolved. The operating system of integrated lean supply chain in real estate puts forward a lean management mode which can realize process integration, organization integration and information integration. This paper optimizes a lean thinking-based model of integrated supply chain in real estate that effectively integrates both inner and outer resources of the real estate enterprises. The internal and external nodes in the supply chain can be corresponded through an information service platform, integrating the logistics platform and the financial flow platform effectively which realizes the integration of information and resources in the supply chain. It can help real estate enterprises to acquire a new management concept so as to enhance their competitive advantages through the organizational integration, the process integration, and the informational integration.

Keywords Information service platform · Lean supply chain · Project management · Real estate

104.1 Introduction

The real estate industry in our country is facing a cruel and intense competition in which “a seller’s market” is changing into “a buyer’s market”. Therefore, varies of real estate enterprises are forced to dump their old thinking modes and

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management concepts, fundamentally redefine the nature of real estate project development and establish a new model which can adapt market requirements and customer demands. While enhancing their internal control and external management simultaneously, real estate development enterprises must strengthen their internal and external communication and coordination management to form an effective system of project operation management. Seen from the strategic perspective, Li (2009) established the enterprise project management of integrated management mode, which provides a new management model and the thought of long-term development for enterprises'. Song et al. (2012) introduced the supply chain performance analysis and coordination with consideration of strategic customer behavior. Kang (2007) analyzed the related process and relationship in the model of commercial real estate integrated supply chain management. Yang et al. (2006) pointed out that the process can realize lean value management of project and the main measures of value optimization. Wanting to integrate lean thoughts into supply chain and eliminate waste from the flow to reduce cost, Wu and Su (2007) deems that we must focus on the whole supply chain itself. The results show that information sharing can improve general contractors' service level (Xue et al. 2011). The project-based supply chain implements cross-organizational bidirectional incentives strategy can achieve both project value-adding maximization and mutual benefit improvement (Wu 2011). Lean supply chain, composed of real estate enterprises, final customers and partners, can quickly respond changes of the product demands to ensure enterprises' survival, development and expansion in complicated and changeable environment of competition.

104.2 Basic Framework of Lean Thinking-Based Integrated Supply Chain in Real Estate

104.2.1 Development Process of Real Estate Project

In general, project development of the real estate can be divided into four stages: investment decision, preliminary work, construction operation and marketing service. Investment decision includes opportunity seeking and screening, feasibility study, project selection, etc. Preliminary work includes land purchasing, fund raising, relocation, planning and design, etc. Construction operation includes bidding, construction management, acceptance inspection, etc. Marketing service includes marketing planning and management, property management, etc. Hence we got an industrial chain with many professional institutions such as planning programming, construction operation, marketing agency, project consulting and so on. Real estate development enterprises usually entrust specialized organizations to take charge of planning and design, construction, project sales, etc. They also arrange and coordinate various resources, utilize the most helpful development modes to enhance their own competitiveness.

104.2.2 Lean Thinking-Based Integrated Supply Chain in the Real Estate

The real estate supply chain represents the core value of all activities in virtual enterprises, and through it we can find the key process of proliferation of real estate products and services in the light of the value analysis. Cooperative enterprises in supply chain nodes which aim to satisfy customers' demands, work closely with upstream and downstream enterprises in supply chain so as to form complementary advantages and optimize supply chain. With the improvement of lean process in supply chain, the competitive advantage of supply chain can strengthen enterprises' own competitiveness (Feng and Jie 2007). The planning and management of supply chains require properly specifying the participating members and the relationships among them (Cheng Jack et al. 2010). By confirming the core status of enterprises in the development supply chain of real estate, and effectively coordinating its internal and external resources to correspond internal and external resource nodes, we can form integrated supply chain management system on the basis of promoting core competitiveness of enterprises and its development projects. Efficient information service platform enables material flow, information flow and cash flow to be operated swiftly, and it can realize information and process integration of internal processes and external partners in real estate enterprises. Basic structures are shown in Fig. 104.1.

104.2.3 Core Modules

The lean thinking-based operating system of integrated supply chain in real estate is made up of three core modules: process integration module, internal organizing integration module and information integration module. In process integration module, the real estate enterprise, as the core, plays three important roles: effective planning, organization and coordination. It ensures all partners on supply chain to respond the requirements of end customers rapidly. In the internal organizing integration module, the project department, as the core, ensures functional department in enterprise internal nodes to realize lean management and respond the requirements of end customers rapidly. Real estate development enterprises and supply chain cooperative enterprises (the external supply chain) realize efficient communication and collaboration through the integrated information service platform. In order to achieve the life cycle of construction project integration, a new modes of organization should be built to organize the construction project, such as decision-making, implementation, operation and maintenance. Guided by project integrated management, a joint organization should be established in which all parties participate together (Li 2005). In the information integration module's organizational structure, project management team should be established jointly by all cooperative enterprises in supply chain, attaining project high-efficient

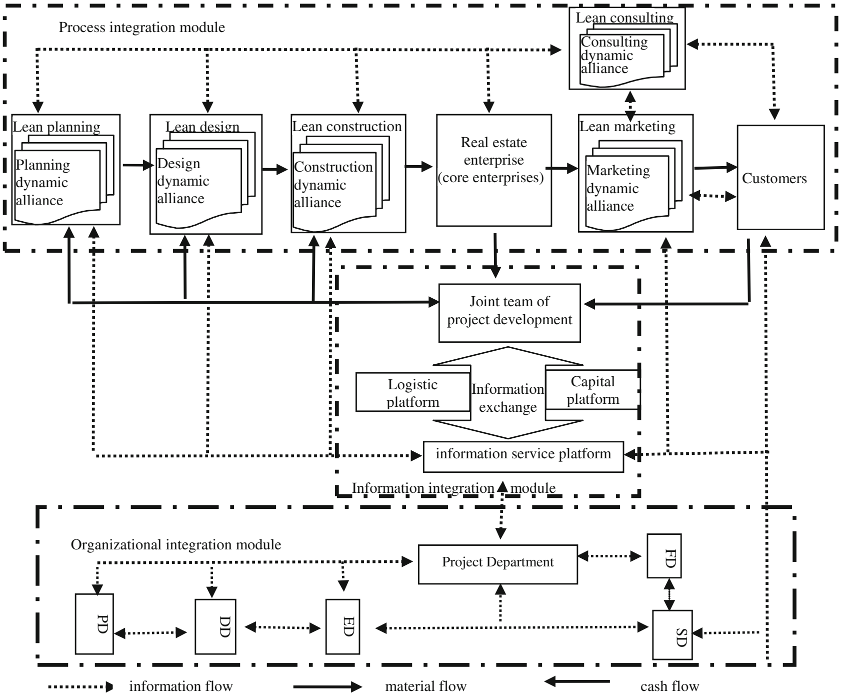

Fig. 104.1 The lean thinking-based integrated supply chain model in real estate

operation through information integration service platform, logistic platform and capital platform. A fair procedure could cushion the effect of an unfavorable decision and thereby reduce a contractor's uncooperative attitude (Aibinu et al. 2008). Project management joint team is a dynamic coalition with dynamic members, variable function, so real estate enterprises are needed to be used as the core of the leadership. Totally speaking, the model of supply chain is very useful for each kind of real estate enterprises.

104.3 The Operating System Analysis of Integrated Lean Supply Chain in Real Estate

104.3.1 Process Integration of Lean Supply Chain in Real Estate

Large project organization is usually composed of multiple dynamic enterprise associations, and each enterprise is autonomy entity with its own distinct professional characteristics in the aspect of management, technology and resources

(Yu and Zhang 2007). Therefore, the traditional simple management patterns of enterprises need to be broken so as to build strategic and dynamic alliance with external enterprises. Supply chain is a dynamic organization, long-term stable and high-quality supply chain is the assurance to success. Process integration module includes several nodes such as real estate enterprises, planning dynamic alliance, design dynamic alliance, construction dynamic alliance, marketing dynamic alliance, consultation dynamic alliance and end customers. Real estate enterprises, as the core in lean supply chain, achieve lean management firstly, pulling other partners in the lean supply chain to realize lean management. The enterprises can integrate their resources, reduce the cost and improve the efficiency through the information intercommunity in supply chain. In the development process of real estate, the enterprises should choose strategic partners according to their own core competitiveness. The project team should involve all appropriate stakeholders while planning the project, depending upon their influence on the project and its outcomes. Through the integration of resource advantages and core competitiveness of all enterprises in the chain, partners' relationship of dynamic alliance in each lean supply chain node is three-dimensional and multi-level integration mode. Real estate development enterprises work as the core with the land development, planning and design, construction, marketing planning and consulting services' participation. Both methods and choices of supply chain partnership are produced by a decision-making process, which involves many factors and multi-objective design. It must maximize the core resources needed by the supply chain, and make partner enterprises in the supply chain to achieve all the "win–win" requirements with minimal risk and maximal profits. Real estate enterprises must establish a reasonable and effective performance evaluation system, enterprise incentive system, reasonable project risk allocation strategies, project profits allocation system, etc., to make partner enterprise cooperate altogether so as to maintain the stability of the dynamic cooperation. Projects can be achieved ahead through all partners' early intervention and feedback reinforcement. Process integration contains system optimization ability which is the upgrade of project development mode.

104.3.2 Organization Integration in Real Estate Lean supply chain

Project Management is necessary and applicable for the proper development of a real estate project (Veas and Pradena 2009). In terms of project management, a real estate project should be run as independent entity, and the traditional management mode of real estate is based on division of labor. Functional specialization often ignores whole project objectives and makes confused coordination. The functional organization of real estate enterprises with high refinement and specialization can only relatively adapt stable competitive environment. Real estate enterprises, as the core in project operation, need to obtain logistics, cash flow and information flow of external supply chain enterprises through its internal related department so as to form the effective integration from external nodes to internal organization. Property managers cope with a wide range of uncertainties, particularly in the early project phases (Reymen Isabelle et al. 2008).

Three levels of real estate enterprises which are grassroots employees, functional departments and top managers can effectively and fleetly respond customers' demands and cooperating partners so as to enhance core competitiveness by mutual cooperation, fluent communication and eliminating multiple leadership. Top management team in real estate enterprises is composed of top managers who are responsible for the strategic decision. They undertake project development strategic management and coordination of macro decision with external nodal enterprises. Middle-level executive team is composed of planning department (PD), designing department (DD), engineering department (ED), sales department (SD), finance department (FD) and project department which is made up of other basic organization (Fig. 104.2).

Project organization is one of the basic functions of Project Management, and the establishment of a scientific and reasonable project organization structure is a key to achieve project target smoothly. To run project successfully, the first important issue is choosing appropriate organization structure according to company's strategy, business, etc. In general, members of project department which is the core of middle-level executive team, come from the functional department to make the whole supply chain continuously developing on the basis of their mutual cooperation. They work and study between the project department and the functional department by turns. In this way, they could be related to specific value stream to share the functional departments' technology, talents and equipments, reducing non-proliferous nodes, improving the ability to create value, and optimizing the operational efficiency of the organization. The functional department, as enterprises' middle-level executive team, should concentrate on the development of its own core technology, systematically accumulate and summarize

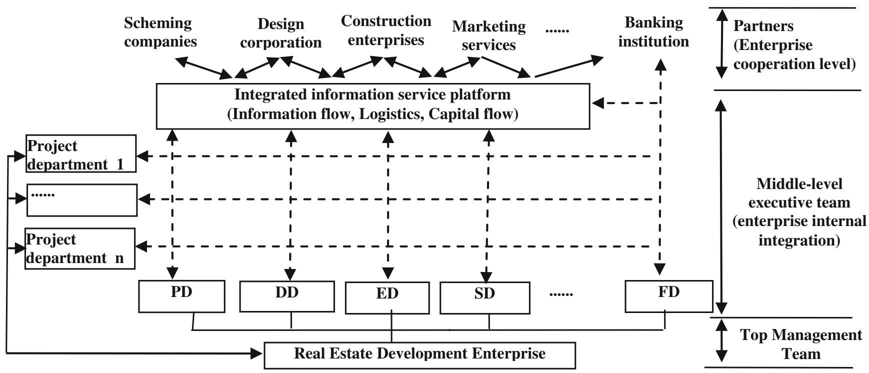

Fig. 104.2 The sketch map of organization integration of real estate enterprises

professional knowledge to explore new knowledge and technology. For example, Sales departments will meet many outstanding marketing agencies while exploring the market, and they can make a file about the material of marketing agencies and their evaluation to which would help them to have clear aim in search of marketing agencies.

104.3.3 Information Integration of Lean Supply Chain in Real Estate

The Information integration module is the central platform of planning and organization. It undertakes the information exchange of enterprises themselves in lean supply chain including their internal nodes and external nodes. In this structure, a joint team, composed of all participants in the lean supply chain project, constitutes the information integration module by the core enterprise. The core enterprise establishes the information integration service platform based on network, as well as the logistics platform and fund flow platform based on it. Using the most effective information communication system, the joint project team can ensure collaborative operation of each node on the lean supply chain, quickly responds customers' personalized demand to realize the swift feedback of logistics, fund flow and information flow. Furthermore, it can realize lean management of the entire value chain. As shown in Fig. 104.3, the information platform is the extension and integration of enterprise information system. Thus Information platform have a basic and guidance role.

Construction industries are not purely technical, but must be accompanied by changes to the management processes (Froese 2010). For real estate enterprises, internet information service platform can achieve e-commerce, synchronization operation, and resource sharing. Numerous partners are involved in the process of project development. Facing a large number of terminal customers, the standardized, digital and modeling integrated information service platform can provide complicated deep service for all partners in the lean supply chain of real estate to realize the largest market value and profit. The information integration service

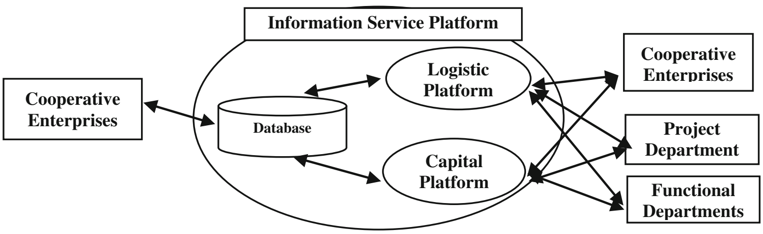

Fig. 104.3 The sketch map of information integration management

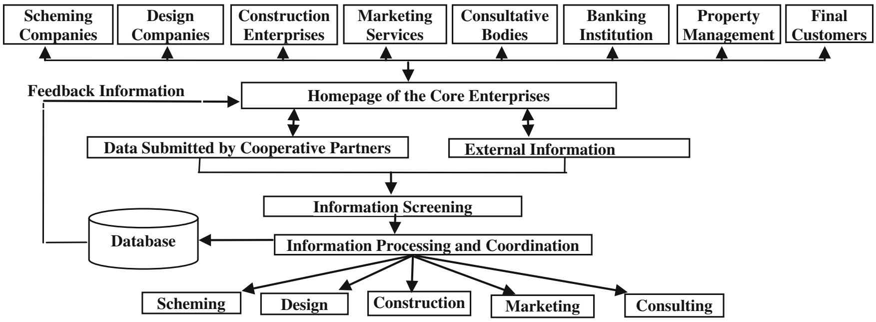

Fig. 104.4 The service platform for information integration based on Internet

platform effectively ensures the effective operation of the logistics and fund flow. It can provide systematic, specialization, integrated information and decision consultation for enterprise development strategy and daily operation, and then guarantee both the quality and quantity. Figure 104.4 is the service platform for information integration from Internet.

104.4 Conclusion

This paper optimized a model of lean thinking-based integrated supply chain in real estate, which integrates both internal and external resources of the real estate enterprises effectively. The internal and external nodes in the supply chain can be corresponded through an information service platform, integrating logistics platform and fund flow platform effectively. It realized the integration of information and resources of the supply chain in real estate enterprises. It can assist development enterprises in real estate in acquiring a fire-new management concept to enhance their competitive advantages through organizational integration, process integration, and informational integration of project development. Based on Internet technologies, the operating system of integrated lean supply chain in real estate can improve the overall efficiency and core competitiveness of the real estate industry chain. This paper aims at offering some advice to the supply chain management of real estate development enterprise in order to improve the economic development of China.

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Chapter 105
Emergency Procurement Decisions Research of the Supply Chain Based on the Stochastic Programming

Jun-rui Lu, Fan-sen Kong and Ling Zhang

Abstract Supply risk often makes enterprise financial losses. In order reduce the financial ruin in the uncertainty situation, enterprise will reservation capacity from spare supplier. This paper focuses on the issue of decoupling supply risk and disruption risk for the capacity reservation strategy. This paper will build the stochastic mathematical model of reservation and purchasing decision for find the optimal reservation capacity and analysis analyze the impact of decoupling of supply risk.

Keywords Programming · Purchasing decision · Reservation capacity · Supply risk management · Stochastic

105.1 Introduction

Risks in supply chain can be divided into two types: supply break and supply uncertainty based on the probability of occurrences and the degree of performance influence. Supply break means the supplier completely lose the ability to provide any supply. The occurrence of this situation is rare, but when it happens it cause serious damages. For example, in 2000, the chip supplier Ericsson lost about $400 million in sales because of a fire. In 2001, due to the bankruptcy its supplier, car

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manufacturers Land Rover laid off 1400 employees (Burke et al. 2007; Federgruen and Yang 2008; Snyder et al. 2006).

Interruption happens for various reasons: strike, war, natural disasters, terrorist attack, bankruptcy of suppliers, alternative production ability limit, the high degree of dependence on a single supplier etc. Unlike government and social organization, risk emergency protocols of enterprises are based on economics concerns only, thus poses strong economic traits (Burrows 1999; Eglin 2003; Sodhi and Chopra 2004; Tang and Tomlin 2008).

As Jotter (Juttner et al. 2003) pointed out, the enterprise supply chain nowadays has the following trends: (1) More emphasis on efficiency but not validity. (2) Global supply and sales. (3) Centralized production and distribution; (4) Tendency towards outsourcing manufacturing; (5) A small amount of suppliers. These factors not only affect the supply chain structure of enterprise, but also create supply chain risks and exacerbate the impact upon enterprises.

In order to avoid the risk of shortage, common practice is ordering a certain amount of goods in every purchasing period. Under the consideration of number of random fluctuation, supply interruption under the combined action of coupling risk, analysis of decoupling process and the influence of the order spare suppliers.

Enterprise may overlook the supply interruption risk, and maintain its regular suppliers with supply amount uncertainty only. Based on this point of view, Chopra first presented the "optimal" supply strategy during enterprise emergency decision-making, and then gives the optimal decision when enterprise bring the existing supply interruption risk into consideration. Through the comparison of two decisions, the study the separate the two the types of risk: ignoring the supply interruption of the existence of risk will lead to excessive use of the conventional enterprises supplier, and a decreased number of emergency supplies. In their study, supply amount uncertainty occurs in the form of random fluctuation and they suppose that customer needs is constant. The model presented in this paper is different from that of Chopra's. The supplier's performance expectation for certain disturbance will be defined as a random event and the conventional supplier disturbance will be confined to a certain range. In other words, the range of disturbance is smaller than the actual quantity range. This model excludes the circumstance that actual supply outranges order quantity, which was included in Chopra's model. Therefore, the supply disturbance model presented in this paper is closer to the actual situation.

105.2 Literature Review

Supply risk divided into two categories: supply interruption, supply quantity uncertainty base on study background. Tomlin (2009) and Yu et al. (2009) put forward a concept of emergency supply spare supply. This concept refers to enterprises in the use of conventional suppliers with supply risk meanwhile maintain cooperation with spare supplier supply without risk. (The cooperation may need to pay a certain deposit). The price is higher than regular supply, but at the same time the supplier have flexibility. When the supply risk events occur, enterprise can spare for emergency supply by supplier. Tomlin and Wang (2005) put forward a double supply delivery, in order to improve the supply capacity, enterprise use two regular supply delivery supply. Sarkar and Mohapatra (2009) present multi-suppliers purchasing-inventory problem when the demand is tremendous and a single supplier cannot meet the demand, in most cases, the demand is stochastic variable. In the study, the reliability of each supplier and supply price is different. Yang et al. (2009) study the order contracts to consider the risk, it is point to in considering the supplier have regular supply under the premise of risk for enterprises order contracts. Tomlin and Wang (2005) put forward an flexible supply is basis of emergency supply, flexible supply refer to a supplier for multiple products supply at the same time, and a supplier for a product supply of alone supply corresponding strategies. With the background of supply of uncertainty, Tang and Lin (Tang and Yin 2007) put forward the concept of dynamic pricing, it is present the enterprise to regular suppliers first order, and then in the supply of conventional supplier risk after realize (enterprise received regular supply delivery after) to establish the meet customer needs the price. This strategy is applicable to customer demand for the price impact by companies. Tomlin (2009) put forward the concept of substitute products. In places of shortest supply, enterprise will meet customer demand for the product transfer to another product demand by a certain discount mechanism. Chopra et al. (2007) study the supply of the risk including supply number of random fluctuation and supply interruption under the combined action of coupling risk, analysis of decoupling process and the influence of the order spare suppliers.

Enterprise may ignore the supply interruption risk, and maintains its regular suppliers with only supply amount of uncertainty. Chopra presented first in this view of enterprise use under emergency supply strategy "optimal" decision-making, and gives the enterprise considering the existing supply interruption when risk optimal decision. Through the comparison of two decisions, the study the separate the two the mold of risk: ignore the supply interruption of the existence of risk will lead to excessive use of the conventional enterprises supplier, and decrease number of use emergency supply. In their study, supply amount of uncertainty for random fluctuation and suppose that customer needs is constant. In this paper presented model and the model Chopra is different, the supplier's performance expectations for certain disturbance is random event. However, the model will be defined as the conventional supplier disturbance interval, in other words is the range of disturbance in less than the actual quantity is open interval. In this model does not appear which in Chopra model of the actual mentioned in greater than the order quantity. The presented model describes the supply of disturbance and more tally with the actual situation.

105.3 The Supply of Risk Identification

Compared with the supply interruption, the probability of occurrence in a conventional risk is higher, but the influence on enterprises is relatively small. Types of risk will be present according to conventional causes in the following order:

Supply quantity uncertainty caused by the supplier's production fluctuations. The fluctuations caused by conventional supplier actual supply quantity and enterprise order quantity are different. The product quantity is enterprise received the random variable and the realization of the product of the enterprise order; Random fluctuation, the amount of enterprise products fluctuates in a certain range. The amount of products is the sum of random variable and the actual quantity; Random supply capacity refers to the unknown value of a supplier's effective production capacity. The amount of products enterprise received is the smaller one of the random variable and the realization of the quantity. Supply price uncertainty: exchange rate changes, and use single supplier strategy lead to purchase price fluctuation; Intellectual property risk: outsourcing production to intellectual property rights of enterprises damage.

In this paper, the supply risk identification, risk formation mechanism based on risk formation mechanism. Through dynamic supplier information analysis of the data, it determines the nature and characteristics of risk and the influencing factors, and provide basis for the risk management control.

To illustrate the supply quantity by two kinds of risk are coupling. The following analysis a corn processing enterprise in 20 purchase cycle of purchasing plan and actual supply quantity. This enterprise plans to purchase quantity for 100 tons each period, actual availability in the list below (Table 105.1).

Shown in the table the quantity we can find the actual number of conventional supplier delivery can be divided into three groups: normal supply delivery number for 100; the actual number less than conventional supplier delivery plan purchase value; Regular supply failure that is the quality equal to 0. In order to facilitate the analysis we assume this three kinds of events are independent and for exclusive events.

Table 105.1 Delivery amounts

Procurement period	Delivery amount (unit: ton)	Procurement period	Delivery amount (unit: ton)
1	100	11	100
2	78	12	70
3	100	13	70
4	60	14	63
5	62	15	85
6	75	16	100
7	100	17	77
8	88	18	55
9	0	19	100
10	83	20	80

The number of suppliers that affect supply reason is single, each issue number with independent supply distribution function $g(y)$. First, data in the Table 105.1 are divided into two classes: the number of supply for 100, and the number of less than 100. That is normal and abnormal supply. The mean of this data is $\overline{y} = 67.57$, standard deviation is $s = 21.85$. Base on the Chebyshev law.

$$z = \frac{(y - \overline{y})}{s} = \frac{(0 - 67.57)}{21.85} = 3.09 \tag{105.1}$$

According Eq. (105.1), the probability of $y = 0$ belongs to the distribution $g(y)$ is mere 0.2 %. Therefore, negative original hypothesis and believe the event come from different population.

105.4 Supply Risk and Emergency Purchase Decision Model

Consider a single period problem where the buyer faces a fixed demand D over the coming period. The buyer has two supply options: one cheaper but prone to disruption and recurrent supply risk and the other perfectly reliable but more expensive.

In every purchase period beginning, the enterprise to send a certain amount of regular suppliers order, at the same time to spare supplier reserve a certain number of ability. When conventional supply delivery risk occurred (supply quantity not sure and supply disruptions), enterprise to spare supplier issued a formal order, which use the reservation of the beginning ability, and payment of the corresponding fees. When conventional supplier and spare supplier offers capability can satisfy occurs when the enterprise out of stock, this time the enterprise will bear the shortage cost.

105.4.1 Symbol Definition and Basic Assumptions

Assumptions: (Table 105.2)

1. The model is a have two types of supplier and enterprise component of the supply chain.
2. The probability of normal supply is P.
3. The occurrence of conventional supplier of the disturbance of supply for probability.
4. The probability of supply uncertainty is Q, random supply amount x in $(0, D)$, and the cumulative probability distribution function is $G(x)$.
5. Constant quality of order in each period is D.
6. When shortage occurs, the shortage cost is h per units.
7. According to the regular supplier capacity use the reserve capacity.

Table 105.2 Symbol definition

Symbol	Description
D	The constant demand of the downstream enterprises for fixed units: tons
x	Supplier supply quantity x in $(0, D)$ Support density function $g(x)$
I	The downstream enterprises upstream suppliers on standby reserve number ability, $I < D$
h	Unit reserve costs
c	Unit shortage cost
e	Unit reserve capacity use cost

8. Shortage cost more than the sum of reservation cost and reservation use cost.
9. Reservation costs do not return.

105.4.2 Supply Risk and Emergency Cost

Consider several supply situations. First of all regular suppliers in normal supply state, regular supply and enterprise order is consistent. But given that regular supplier supply risk, the enterprise had to completely reliable supplier of reservation capacity. The strategy makes the enterprise reduce the loss brought out of stock when the supply risk occurs. Meanwhile, the enterprise will burden reservation ability cost, in this called emergency costs.

When regular supplier actual supply less than your order D, then they consider use the spare supplier reservation. However, when regular supplier delivery amounts small, use of all of the reservation ability also cannot satisfy your order. Enterprise will burden reservation cost, reservation use cost and shortage cost.

When conventional supplier delivery disruptions occur, will inevitably occur out of stock situation. The supply situation, and corresponding cost in the list Table 105.3.

Table 105.3 Supply risk and composition of emergency cost

Regular supplier availability	Description	Composition of Emergency cost
Regular supply	Regular suppliers meet the demand of enterprise fixed downstream	Reservation cost
Supply uncertainty	Use spare supplier delivery, when $x < D - I$	Shortage cost, Reservation cost, Reservation use cost
	In the opposite, when $x > D - I$ can meet supply requirements	Reservation cost, Reservation use cost
Supply interruption	Delivery amount is 0, a serious shortage. Shortage mounts equal to $D - I$	Shortage cost, Reservation cost, Reservation use cost

105.4.3 Reservation Capacity Optimization

Emergency cost expectation calculation in different supply situation:

Situation 1: Regular supplier normal supply, cost function is $t(I)$.

$$E_P[t(I)] = P \times I \times h \tag{105.2}$$

Situation 2: Regular supplier delivery uncertain number,

$$\mathrm{E}_Q[\mathrm{t}(I)] = \mathrm{Q}\begin{bmatrix} \mathrm{hI} + \mathrm{eI}\int_0^{D-I}\mathrm{dG}(x) + \mathrm{e}\int_{D-I}^{D} D - XdG(x) + \\ \mathrm{c}\int_0^{D-I} D - X - IdG(x) \end{bmatrix} \tag{105.3}$$

Situation 3: Regular supply delivery interruption,

$$\mathrm{E_M[t(I)] = M[hI + c(D - I)]} \tag{105.4}$$

Total cost for emergency expectations:

$$\mathrm{E}_{total}[\mathrm{t(I)}] = \mathrm{E}_P[\mathrm{t(I)}] + \mathrm{E}_Q[\mathrm{t(I)}] + \mathrm{E_M[t(I)]} \tag{105.5}$$

The derivative cost function:

$$\frac{\partial E(t(I))}{\partial I} = Ph + Q(h + (e - c)\int_0^{D-I} g(x)dx) + M(h + e - c) \tag{105.6}$$

Set the derivative cost function equal to zero:

$$I = D - G^{-1}\left(\frac{-Ph - M(h + e - c)}{Q(e - c)} - \frac{h}{e - c}\right) \tag{105.7}$$

Function $G^{-1}(x)$ is the inverse function of $G(x)$.

The second partial derivative:

$$\frac{\partial^2 E(t(I))}{\partial I^2} = -Qe \times g(D - I) \tag{105.8}$$

Prove the $\frac{\partial^2 E(t(I))}{\partial I^2} > 0$, then $E(t(I))$ is the concave function. Emergency cost function has the optimal solution. The optimal solution is I^*.

$$I^* = D - G^{-1}(\frac{-Ph - M(h + e - c)}{Q(e - c)} - \frac{h}{e - c}) \tag{105.9}$$

Table 105.4 Index and value

Index	*D*	*P*	*Q*	*M*	*h*	*e*	*c*
value	100	0.5	0.4	0.1	1	3	6

105.4.4 Case Study

Take the table (Table 105.4) index plug into (105.9).

The optimal conservation amount is 41 tons each period. The figure (Fig. 105.1) is the emergency cost of different conservation amount.

105.5 The Risk of Supply Coupled

Now to analyze another situation: Supply the uncertain number and supply interruption coupling condition. In the situation we consider the interruption is the part of supply uncertainty and suppose that the two events from the same population.

Now we compared the supply uncertain number and supply interruption to the optimal reservation ability influence in different situation. In this situation, the probability of uncertainty is equal to the sum of Q and M in former situation. Compared with Table 105.4 Q is equal to 0.5 and M is equal 0. Take the table index plug into (105.9), and get the Fig. 105.2. Curve 1 indicate risk of supply decoupling, and Curve 2 indicate the risk of supply coupled.

As can be seen from the graph, the risk of supply coupled lead to high emergency costs. The result is contrary to the Chopra's study. The result is caused by risk supply decoupling and the model amplify the risk of stock. The overestimated risk lead to the high optimal reservation amounts and produce more emergency costs.

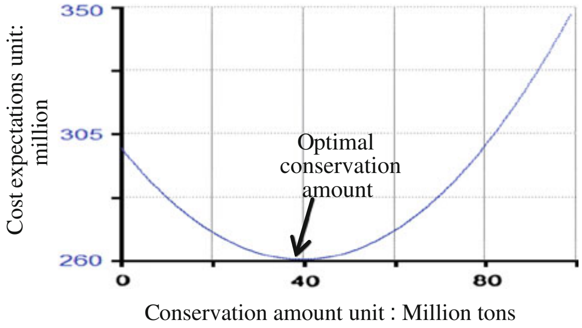

Fig. 105.1 Emergency cost graph

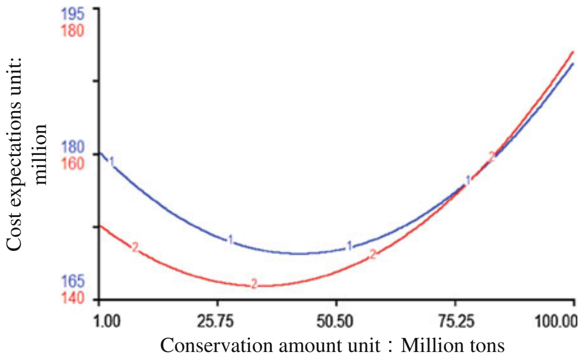

Fig. 105.2 Supply risk coupling emergency the cost graph

In a particular supply risk level, supply interruption (Supply uncertainty) underestimate (overestimate) may lead to regular supplier not sufficient use and the excessive use of spare suppliers.

105.6 Conclusion

In this paper, study the statistical method to identify the risk of supply category methods, and, present optimal purchasing decision in an uncertainty situation. The paper concludes that the more enterprise regular supplier order or conventional more reliable suppliers (supply interruption probability or improve the rate of decrease random supply). The less enterprise should set aside suppliers to make an appointment fewer production ability; Along with the increase of the supply interruption probability, the enterprise should be increased to spare supplier spare production capacity reservation.

In other ward, the decoupling supply of risk to supply is good for analysis to the risk. However, the application unsuitable model may lead to supply the risk to mistake, and then lead to the increased cost of emergency

105.7 Prospects

In this paper, the supply risk identification is divided into supply quantity uncertainty and supply interruption, the risk of further refinement to supply from supply to the deep reasons of the risk. In addition, the development of this single period model need to expand multi-period model which is still has a lot of factors need to be considered, such as price fluctuations, quantity fluctuation. Moreover, parameters set and supply the uncertain number forms (distribution) and the probability of supply risk have huge impact on emergency costs.

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Chapter 106
Empirical Study on Influencing Factors of Regional Imports in China

Ping Yi, Wei-wei Cheng, Liu-mei Hu and Xiang-mao Li

Abstract The unbalance of the inner structure of import is more and more serious with the sharp increasing of foreign trade in China. The data of 31 provinces in China from 2002 to 2011 is used to examine the relationship between the import and export, fixed-assets investment, financial revenue of government through a panel data mode of variable coefficient. Empirical research suggests that both export and financial revenue have positive effect on the import while fixed-assets investment is opposite. Only export affects significantly, and great difference of the same factor is shown in each province. Finally, effective suggestions and policies are put forward according to the result.

Keywords Empirical research · Export · Financial revenue · Fixed-assets investment · Import

106.1 Introduction

With the reform of China's economic system, China's imports keep sustainable growing. The imported trade has increased nearly 40 times from \$43.2 billion to \$1.7435 trillion from 1987 to 2011, while each regional import is extremely uneven. In 2011, the highest is \$381.54 billion, in Guangdong, followed by Beijing (3,305), Shanghai (2,277), Jiangsu (227). And the imports of the low-ranking province, like Guizhou, Ningxia, Qinghai are only equal to 0.5, 0.24, and 0.07 % of that of Guangdong. Tibet's import (only \$175.5 million), ranking the last one,

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equals 0.05 % of Guangdong. Great differences in China's local imported trade have further intensified the regional imbalance of economic development and affected implementation of China's strategy of "the great development of the west" and "the rise of the central region" as well. In this context, exploring the way to solve the imbalance of regional foreign trade is the most urgent task in coordination of local economy development under current new financial economical environment.

106.2 The Domestic and Oveseas Researches

106.2.1 Dynamic Situation of Overseas Research

Before the 1960s, foreign scholars research impact factors of imports mainly from resources endowment (H–O theory). After the 1960s, they focus on the following aspects: (1) From the demand preference and income level, Swedish economist Linder proposes the overlap demand theory that the more overlap demand of two countries, the greater potential of trade (Linder 1961) (2) Foreign direct investment: Heckscher Eli F puts forward that there are complement and promotion between foreign investment and imports (Heckscher 1919). V • ORTS and Pen a lope Pacheco-Lopez hold that foreign direct investment not only promotes exports of Spanish or Mexican, but also leads to higher imports (Orts 2003; Pacheco-Lopez 2005). (3) Exchange rate fluctuations: Catao and Elisabetta and M.F aruk Aydin hold that relationship between import and actual exchange rate is significant (Catao and Falcetti 1999; Faruk Aydin et al. 2004) (4) Institutional factors: Jens Ulff-Moller concludes French quota system limits the import of American films (Ulff-Moller 2009). Marc Allen holds that China's import trade is positively influenced by Agreement on Commodity Trade of CAFTA (Marc 2008).

106.2.2 Dynamic Situation of Domestic Research

Chinese research can be divided into two levels: (1) From the national level, Yao Lifang, Wei Weixian, Xiong Xiaolian, Xu Helian, Li Pengbo conclude that the main impact factors are GDP, savings deposit, utilization of foreign capital, exchange rates, export, import tariff rate, foreign trade management (Yao Lifang 1998; Wei 1999; Xiong 2002; Xu and Lai 2002; Li 2009). Zhang Peng holds that there are two-way granger causality between agricultural imports and the farmers' income in the long term (Zhang and Xie 2007). Fan Jingjing concludes that China's dairy import is influenced by production, income level, price, substitution (Fang 2008). (2) Local level: Yan Haixia holds that the effects of GDP, export trade and foreign direct investment of Jiangsu province on import trade are positive (Yan 2008). The results of Zhou Huijun show that economic growth and import trade of Shanghai are stable (Zhou et al. 2009). Hang Yanyong holds imports in Zhejiang province are mainly affected by political measures, management system, service function, trade pattern (Hang 2009).

The literature above strives for development and perfection mainly from modeling, diversity, equalization. But most researches are from national or special region level, without consideration of regional differences. As to method, time series method is applied most, while panel data less. If only explain import trade development of various areas by national level, it will attribute to deviation without doubt.

106.3 Impact Factors on Reginal Import

106.3.1 Regional Imports Trade in China

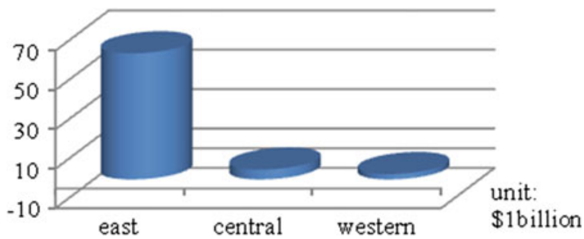
No matter the scale or the structure, China's foreign trade receives considerable development. From 1980 to 1999, the average annual growth is 11.7 percent. Specifically, it jumped by 23.5 percent in 2000, and China's foreign trade takes a third in the world in 2007. The paper focuses on regional imports.

From Fig. 106.1, China's import trade mainly concentrates on the eastern region, and the amount reduces gradually from the east to the west. The average import trade of nearly 10 years in eastern region is $64.3 billion, accounting for 89 % of the total average amount of national import. The central region is $5billion, accounting for 7 %. The last one is western region, which is only $2.7billion, accounting for 4 %. This obvious zone tilt pattern reflects extreme imbalance of internal structure of China's foreign trade. Why there are so big differences in deferent regions? It needs to explore the main import factors of imports.

106.3.2 Influence of Export on Import

On the surface, export and import have no inner link; however, both are tightly linked. As China's foreign trade concentrates on manufacture and most is

Fig. 106 1 Average import trade of three areas in China during 2002–2011



processing trade. A large part of the processing trade belongs to the material processing, which leads to a big increase in the number of imports. At the same time, since the open market policy is taken, problem of resource shortage is more and more serious; therefore, large imported demand of middle product and raw materials increases imports.

106.3.3 Influence of Fixed Assets Investment on Import

The fixed assets investment is economic activities of construction and purchase. Great expansion of domestic production pushes import demand of the machine equipment, advanced technology and equipment. On one hand, import is the forerunner of foreign investment, on the other hand, after multinational companies invest in China, a large number of machine equipment,raw materials and spare parts were imported continuously.

106.3.4 Influence of Financial Revenue on Import

More than 80 % of China's financial income is tax. The more tax amount is, the less per capital disposable income is, which restrains demand, the negative effect of tax. Generally, the financial revenue goes with national income. After tax, some purchasing powers of residents turn to import high-grade durable consumer goods, technologically intensive electronic products, expensive luxury, which shows tax's positive effect.

106.4 The Set of Mode

This paper constructs a panel mode as in

$$IMP_{it} = \alpha_{it} + \beta_{1it}EXP_{it} + \beta_{2it}FAI_{it} + \beta_{3it}LFR_{it} + \mu_{it}, \tag{106.1}$$

$i = 1, 2 \ldots 31$; t = 1, 2 …10. IMP_{it}, EXP_{it}, FAI_{it}, LFR_{it} represent import, export, fixed assets investment, local financial revenue of different periods in regions, μ_{it} means random disturbance and meets the basic assumptions of classical econometric model. E(μ_{it}) = 0, Var (μ_{it}) = σ^2u, μ_{it}-N (0. σ^2u).The influence of three independent variables on import can be reflected by the coefficient. If estimated coefficient is both significant and greater than 0, the variable creates new import demand. Otherwise, the variable has substitution effect of import trade. If the coefficient is not significant, the variable has indirect relationship.

106.5 The Sample, Data and Method

Based on theory analysis above, 31 provinces in China are selected as samples, annual data from 2002 to 2011 is employed since China joins WTO while import is set as dependent variable, export, fixed assets investment and financial revenue are set as independent variables to empirically analyze on impact factors of regional imports. All data comes from China's statistical yearbook and WB.

Panel model is classified into variable coefficient, variable intercept and constant coefficient. Covariance inspection is often used to select. Now two hypotheses are proposed.

$$H_1 : \beta_1 = \beta_2 = \Lambda = \beta_N;$$
$$H_2 : \alpha_1 = \alpha_2 = \Lambda = \alpha_N, \beta_1 = \beta_2 = \Lambda = \beta_N$$

And following statistics are constructed to test the hypotheses:

$$F_1 = \{(S_2 - S_1)/[(n-1)k]\}/\{S_1/[nT - n(k+1)]\} - F[(n-1)k, nT - n(k+1)]$$
$$F_2 = \{(S_3 - S_1)/[(n-1)(k+1)]\}/\{S_1/[nT - n(k+1)]\} - F[(n-1)(k+1), nT - n(k+1)]$$

Given the level α, if F_2 is less than F_α, then accept the hypothesis of $H2$, and choose constant coefficient model. Otherwise, continue check. If $F1$ is less than F_α, then accept the hypothesis of H_1 and choose variable intercept model. Otherwise accept variable coefficient model. Hausman test is used to choose effect or random effect in this paper.

106.6 The Empirical Analysis and Inspection

106.6.1 Covariance and Hausman Inspection

Table 106.1 shows that because F_2 is more than $F_{0.05}$ (90,186), so refuses H_2. As F_1 is more than $F_{0.05}$ (90,186), so refuses H_1. Finally variable coefficient model is chosen. Hausman statistic value is 400.487 and the corresponding probability value is 0, which means inspection results refuse the null hypothesis of random effect so the fixed-effect model should be established. In all, this paper selects variable coefficient model of fixed effect to analyze.

Table 106.1 Result of covariance and Hausma inspection

Covariance inspection	Value	Hausman Inspection		Value
F_1	19	Chi-Sq		400.487
F_2	55.8	p		0.00000
$F_{10.05}(90, 186)$	1.31			
$F_{20.05}(90, 186)$	1.31			
Sum squared resid				
S_1 1.7E + 15	S_2	1.80E + 16	S_3	6.50E + 16

106.6.2 The Analysis on the Regression Results

From Table 106.2, it is known as coefficient of determination is 0.995 and p value is 0.000, it provides a good explanation for overall estimation of this model, which means dependent variables have significant correlation with independent variable. However, from individual estimation, there exist obvious differences. The same factor shows positive or strong to some areas, but negative or weak to others.

(1) *The differences of regional export trade influencing on import trade:* From Table 106.2, export of 23 provinces shows positive correlation and the total coefficient is 12.89, which indicates most regions' export creates import while small areas' export substitutes import. For the positive effect, Bejing, Gansu, Inner Mongolia, Shanghai list in the front, followed by Shandong, Chongqing, Shanxi, and Tibet. Furthermore, Beijing, Shanghai, Jiangsu, Guangdong, Tianjin, Shandong, Zhejiang satisfy 0.05 lever of significant inspection. Taking Beijing as an example, export increases every one unit on average, import increases 1.57 units on average directly. In contrast, export of Heilongjiang, Xinjiang, Qinghai and Guangxi has negative effects and doesn't pass significant inspection, indicating effect is indirect.

(2) *The differences of regional fixed assets investment influencing on import trade:* Fixed assets investment of seventeen districts affects negatively while others positively. The total correlation coefficient is negative 4.27, which indicates it has substitution effect on import. Arrange by the positive coefficient, Jiangsu, Zhejiang, Guangdong, Shanxi provinces list in the front, followed by Sichuan, Liaoning, Hebei and others. But they all don't pass significant test of 0.05 levels. In contrast, districts of negative coefficient listed in the front are Beijing, Shanghai, Hainan Guangxi, followed by Shandong, Ningxia, Guizhou. Only Beijing and Shanghai pass significant test. Two developed cities increase investment every one unit, imports will reduce 2.65 and 1.4 units on average directly.

(3) *The differences of regional financial revenue influencing on import trade*: Similarly, 22 regions' financial revenue affects import positively while the rests are opposite. That the total correlation efficient is 28.56 reflects most have creative effects on import. Arranged by positive coefficient, districts listed in the front are Beijing, Hainan, Guangxi, Jiangxi, and Shanghai, followed by Zhejiang, Shanxi, Xinjiang, Guizhou and Hunan. Among them, Beijing and Shanghai pass the

Table 106.2 The regression results of model

Cross-section fixed(dummy variables)

Province/city	C_EXP	C_FAP	C_LFR
Beijing	1.57*	−2.63**	9.08**
Tianjin	0.59*	−0.08	1.56
Hebei	0.9	0.01	−0.25
Shanxi	0.24	0.07	0.05
Inner Mongolia	1.17	0.05	−0.39
Liaoning	0.4	0.01	0.39
Jilin	0.16	−0.03	1.54
Heilongjiang	−0.03	−0.04	1.25
Shanghai	0.91*	−1.41**	1.74**
Jiangsu	0.63*	0.23	−1.12
Zhejiang	0.21**	0.19	0.09
Anhui	0.7	−0.03	0.37
Fujian	0.4	−0.07	0.8
Jiangxi	−0.5	−0.07	2.13
Shandong	0.32**	−0.01	1.37
Henan	0.51	0.03	−0.14
Hubei	0.9	0.01	−0.25
Hunan	−0.15	−0.03	0.79
Guangdong	0.62*	0.09	−0.33
Guangxi	−0.51	−0.11	2.55
Hainan	−0.44	−0.47	4.05
Chongqing	0.29	0.04	−0.1
Sichuan	0.71	0.02	−0.14
Guizhou	0.72	0.01	0.01
Yunnan	0.99	0.05	−0.41
Tibet	0.02	−0.01	0.11
Shanxi	−0.13	0.04	0.09
Gansu	1.37	−0.08	1.66
Qinghai	−0.05	−0.06	0.66
Ningxia	0.4	−0.01	0.24
Xinjiang	−0.04	0.05	0.05
R-squared	0.997	Adjusted R-squared	0.995
F-statistic	462.7	Prob(F-test)	0.000

Note *, ** represent t-statistics passing significant test of 0.01 & 0.05 level respectively

significant test of 0.05 levels, that is, their local financial revenue creates import directly. Both increase financial revenue every one unit, demand of import increases 9.08 and 1.74 units correspondingly. In contrast, districts of negative influences are Chongqing, Henan, Sichuan, and others. They don't meet significant test, so effect is indirect.

106.7 Conclusions and Suggestions

106.7.1 Conclusions

In summary, export and financial revenue have positive effects on import, but fixed assets investment has negative effect. Why the same import factor on different regions has positive or negative, strong or weak effect?

As the prosperity of export trade boost China's intermediates and raw material greatly, export trade influences on imports positively and directly. Regards the creative effect of financial revenue is indirect, it results from that increasing local finance and tax restrain effective demand. In fact, residents' income is used for necessities at first, so the rest purchasing power of foreign import is relatively low. In condition, investment in China concentrates on mainland, only little is toward foreign and Hong Kong, Macao and Taiwan. Equipment imported from overseas is far less than the large-scale investment of infrastructure construction; therefore, investment has substitution effect on import.

Import factors of most samples accord with theoretical assumptions, only a few are abnormal. For example, export of Hunan, Hainan, Jiangxi, and Heilongjiang has negative effect on import. Along with export increasing, import will drop little instead by little proportion of processing trade. As political and cultural center in China, large-scale infrastructure investment and less inflowing foreign capital of Beijing further weaken imports. Guizhou and Tibet are backward, and most investment is infrastructure construction, so the effect is negative. Financial revenue of Guangdong, Jiangsu, Hubei has negative effect on import. On one hand, increasing fiscal revenue reduce disposable income of residents directly; on the other hand, direct consumption preferences of urban residents is far less than that of savings because of dramatically rising price of house or goods. But financial income of Beijing and shanghai has significant creative effect, because speed of increasing tax is far less than that of resident income. In addition, the unprecedented development of foreign trade, advanced logistics industry and large supply of import substitution stimulate purchase power of imports directly.

106.7.2 Political Suggestions

Since import factors influence on regions differently, corresponding measures can be taken to expand regional imports and stabilize balance of foreign trade in China. The empirical analysis shows that export is the most significant factor. For relatively little positive efficient, Chongqing, Shanxi, Zhejiang, Tibet can expand export trade. For the negative samples, Guangxi, Jiangxi, Hainan, Hunan can adjust export structure appropriately and develop all kinds of useful policies. In terms of fixed assets investment, Jiangsu, Zhejiang, Guangdong, and Shanxi can increase investment and create better environment for attracting more foreign investment. Beijing, Shanghai, Hainan, Guangxi, Gansu can adjust the proportion of investment and structure for reducing negative effects. As to financial income, governments of Beijing, Hainan, Guangxi, Jiangxi, and Shanghai can increase local financial revenue to make full use of creative effect. Residents of Jiangsu, Yunnan, and Inner Mongolia, Guangdong can change consumption preferences of residents to increase imports. Especially, that government announces measures of controlling house prices and goods will stimulate demand of imports in a certain degree. At the same time, China can strengthen independently innovation of export products and learn from advanced western technology to optimize industrial structure. All this can make international trade of China toward internal balance and realize the grand strategy of comprehensive, coordinated and sustainable development.

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Chapter 107
Hybrid Positioning Mode of VOP and OPP in Demand-Supply Chains

Xu-mei Yuan, Ling Zhang and Jalal Ashayeri

Abstract In traditional supply chain management, suppliers usually have to balance their cost and the service they offer to customers, while nowadays they are trying best to improve their efficiency as well as the service offered. Therefore, it becomes crucial for suppliers to modify the Demand-Supply Chain. The impacts of value offering point and order penetration point on supplier's and customer's costs and benefits are illustrated in this paper. Through analyzing the position of both in the Demand-Supply Chains of manufacturing industry, 17 hybrid positioning modes of VOP and OPP are proposed.

Keywords Demand-supply chain · Hybrid positioning · Order penetration point · Value offering point

107.1 Introduction

During the past, suppliers reduced their obsolete inventory and cut down cost and time of goods to the market for reengineering the supply chain, but only their end. However, nowadays with the economy developing rapidly, the market demand becomes more customized while the product life turns shorter. A much more powerful concept lies in the Demand Chain. Holmstrom et al. (2001) proposed the management of Demand-Supply Chains together, and these are linked and

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managed in two places—the Value Offering Point (VOP) and the Order Penetration Point (OPP).

This paper analyzes the difference of supplier's and customer's costs and benefits, which are caused by the various positions of VOP and OPP (Ge et al. 2008), and then proposes profiles of all probable hybrid positioning modes of them, on the basis of a Demand-Supply Chain which includes supplier chain and customer chain of a manufacturing industry.

107.2 Analysis of VOP Position

According to MacMillan and McGrath (1996), suppliers aim to offer their customers special value that competitors lack to gain the most profits. Suppliers could basically do that at every point where they contact with their customers. As the customer value increases in discontinuous step typically, it is vital to find those significant increase points (Auramo and Ala-Risku 2005), which are also called value thresholds for the Demand-Supply Chain.

The supplier should position the VOP at the value threshold in the customer's demand chain (Kaipia et al. 2007). In practice, the customer could get the benefits largely, while the supplier has to do more work if the VOP moves upstream of the demand chain. Holmstrom raised three principle VOPs—"offer to purchasing", "offer to inventory management" and "offer to planning".

As for a demand chain includes the "designing", "planning", "inventory management", and "purchasing", which is the same as a supply chain, this work illustrates four alternatives VOPs given in Fig. 107.1.

VOP1 is defined as the VOP of the supplier which is in the customer's purchasing department, in a conventional buyer–seller relationship. The buyer in customer's organization should balance the best buy with the transaction cost before the decision of which supplier to choose to fulfill its need.

VOP2 is defined as the VOP which is moved further upstream in the demand chain. In that situation, the supplier manages its customers' inventory. It guarantees enough goods in stock and decides when to do the replenishment instead of its customer. As a result, the supplier has to pay more for a higher level of the process integration. Only a few key suppliers are committed to by the customer when the customer–supplier relationship is really working.

VOP3 is defined as the VOP which moves back to the planning department of customer. This kind of collaboration could help both supplier and customer to avoid the new products or promotions which lack market, and help the former to improve its delivery performance. However, the supplier won't benefit from it, unless it could increase its sales or charge an extra premium, although customer could get more profits.

VOP4 is defined as the VOP that is the "offer to designing". It moves all the way back to the end customers of demand chain. Suppliers fulfill orders for

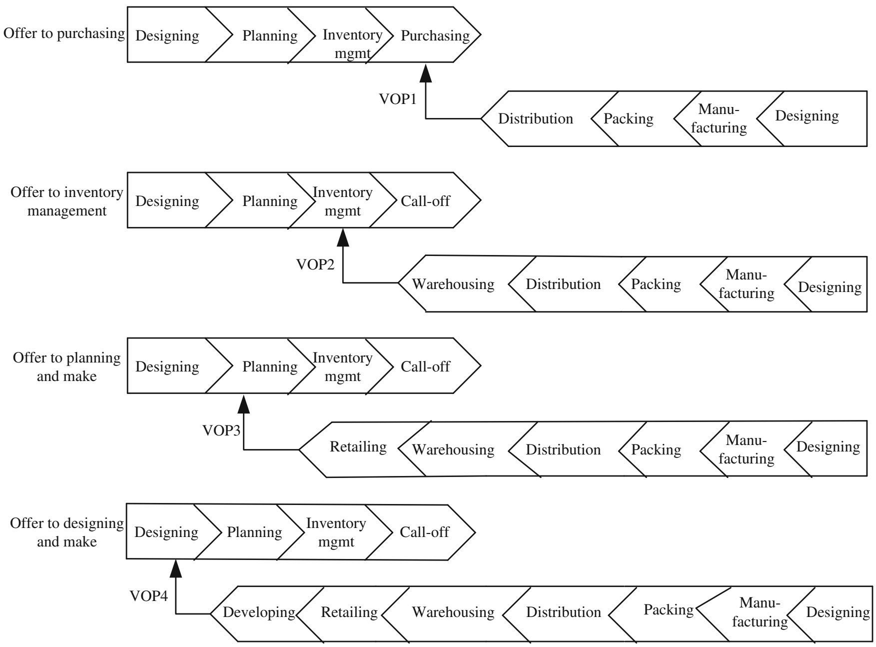

Fig. 107.1 The value offering points in demand chain

complete customized products with information totally shared. Customers could get the maximum profits, while suppliers have to afford the most integration cost.

107.3 Analysis of OPP Position

107.3.1 Traditional OPPs

Different positions of the OPP are related to different manufacturing situations, which relate to the manufacturing ability to accommodate to the customization and wide range of products (Olhager 2003), see Fig. 107.2. Thus, the OPP divides the material flow into forecast-driven flow (upstream of the OPP) and the customer order-driven flow (downstream of the OPP).

Olhager (2010) acknowledges that the OPP is the divider between lean and agile operations in manufacturing or supply chains, as the OPP is a strategic stock point.

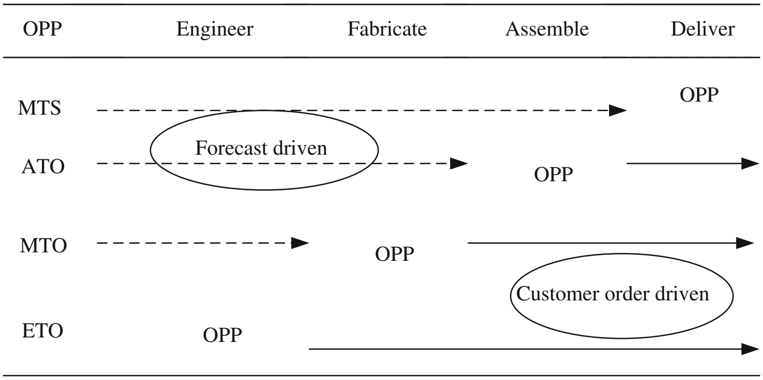

Fig. 107.2 Different order penetration points (based on Jan Olhager 2010)

Table 107.1 Traditional OPPs in terms of two-dimension

Traditional OPPs	Traditional OPPs in terms of	
	Engineering OPPs (ED)	Production OPPs (PD)
ETP	ETO	MTO
–	ATO	MTO
MTO	ETS	MTO
–	ATO	ATO
ATO	ETS	ATO
MTS	ETS	MTS

Source Wikner and Rudberg (2005)

107.3.2 Two-Dimensional OPPs

When adopting the traditional positioning of OPP, the production and engineering-related activities are not differed by scholars. In order to show how the OPP concept plays a role to integrate engineering resources with the operational process, Rudberg and Wikner (2004) used two dimensions, production and engineering dimension. Table 107.1 shows the corresponding relationship between the traditional and the two-dimensional OPPs.

According to Table I, there are six basic OPP double positions. It happened to the double [ETS_{ED}, MTS_{PD}] extreme point, that both engineering and production are carried out without customer involvement. At the other extreme double [ETO_{ED}, MTO_{PD}], both all engineering and all production activities are performed according to customer specifications. The others are all based on the level of customer involvement.

107.3.3 OPPs Referred to Postponement

The OPP has close relationship with several other logistics concepts, such as postponement and push–pull concepts. The latter address the initiation of production based on either push (forecast driven) or pull (order driven) or combination of these. The postponement concept is the same and deals with the start delaying of related activities until a real demand comes, for it. To the extent, the manufacturing and logistics operations could be postponed until actual customer order arrives. Then the uncertainty and risk of the relative operations could be reduced, even completely eliminated (Huang and Li 2008). The manufacture and logistics postponement can be considered as two elements of supply chain strategy.

Sharman (1984) refers to order penetration points as different delivery modes, like MTO, ATO and MTS, which can be divided into PTO and STO delivery modes, see Fig. 107.3. According to this concept, only the manufacturing postponement would be referred to by OPP.

107.3.4 Positions of OPP

In the circumstances above, this paper maintains that the applied manufacturing and logistics postponement strategies and the integration of production- and engineering- related activities basically determine the location of the OPP. As the OPP locates in further upstream of the supply chain, the manufacturing and logistics activities are postponed more. The positions of OPP, which are depended on these two axes—manufacturing and logistics postponement, are illustrated in Fig. 107.4.

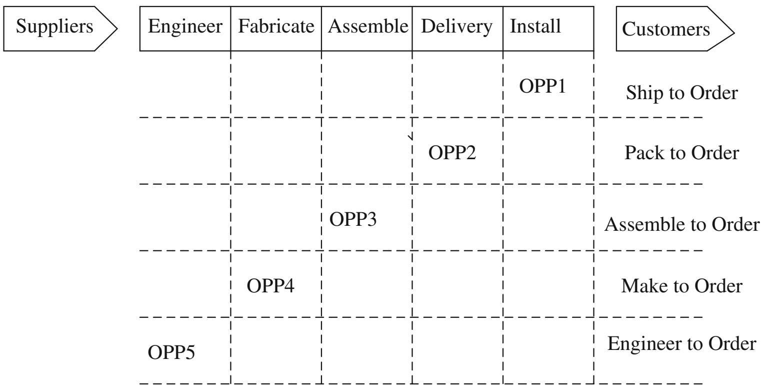

Fig. 107.3 Order penetration points [based on Collin (2003)]

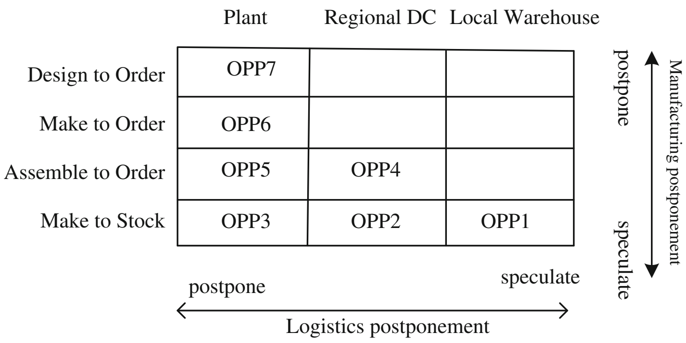

Fig. 107.4 The order penetration points in supply chain

In the MTO mode, supplier can deliver products to customers from the plant warehouse, regional distribution center, or from the local warehouse. Although all the stock is for finished goods, it has a great influence on supply chain management whether the buffer is located inside the plant or whether it is distributed into dozens of local warehouses.

In the ATO mode, the products are stored as modules and kits, rather than the finished goods, in the plant warehouse or the regional distribution center, where suppliers assemble the final product based on a received customer order. The OPP locates in further upstream in this situation in comparison to the one where buffers would consist of finished goods, in the same physical location.

In the MTO mode, the material is stocked in the plant warehouse, where the production starts as soon as a real customer order comes. The OPP locates in much further upstream in this situation compared to the one of ATO mode.

In the DTO mode, the product is designed based on the arrived customer order. In this situation customers are involved in the production process from a very early time. The location of OPP is the furthest upstream compared with other modes.

In other words, both the manufacturing and logistics postponement levels have great influence on the position of the OPP largely. And this work makes out the seven OPPs according to different supply chain strategies, OPP1, OPP2, OPP3, OPP4, OPP5, OPP6 and OPP7.

107.4 Hybrid Positioning Mode of VOP and OPP

The first step of the approach in re-engineering Demand-Supply Chains is to identify the customer's demand chain to achieve the improved customer value. Practically the demand chain transfers the demand from market to supplier, while the supply chain creates goods or services to customers to meet their demand (Hoover et al. 2001). The supplier aims to find such a hybrid position mode of VOP and OPP in the re-engineering approach. It could benefit the supplier if it moves the OPP at the same time, although it largely benefits the customer to move the VOP back. Obviously, it benefits one party at the expense of the other to move the OPP, but the coordinating movements in the both chains can improve customers' performance and simultaneously increase the efficiency of the suppliers' operations (Burn and Hackey 2000).

VOP and OPP could be considered as two central means of differentiating supply chains for individual customers (QuaresmaDias et al. 2010). The VOP connects the customer's demand chain to the supply chain, and the OPP could be considered as a combination of the manufacturing and logistics postponement. This paper uses these two concepts for analysis of customizing and systematically improving the supply chains for customers. Table 107.2 illustrates 17 probable hybrid positioning modes of VOP and OPP, based on the analysis of them respectively above.

(1) VOP1-OPP1: the VOP of the supplier locates at purchasing function of the customer, while the OPP locates at the most downstream of the supply chain, which is the local warehouse of the customer premise. The supplier adopts the make-to-stock strategy, and starts to manufacture in large-scale according to forecast. Then the products will be delivered to the local warehouse which is near from the customer, and sent out directly when the order arrives.
(2) VOP1-OPP2: the VOP of the supplier locates at purchasing function of the customer, while the OPP locates at the Regional Distribution Centre. The supplier also adopts the make-to-stock strategy, and starts mass production according the forecast. However, the finished-goods will be distributed to the Regional DC, from which the goods are delivered to single customer, respectively, according to each order arrived.
(3) VOP2-OPP2: the VOP of the supplier locates at the inventory management function of the customer, while the OPP locates at the Regional Distribution Center. The supplier adopts the make-to-stock strategy. The supplier offer customers the service of inventory management, and make a mass production based on the inventory information shared. Then the products will be distributed to the Regional DC. When the order points of the customers come, the supplier will do the replenishment immediately from the Regional DC.
(4) VOP1-OPP3: the VOP of the supplier locates at the purchasing function of the customer, while the OPP locates at the local plant of the supplier premise. The supplier still adopts the make-to-stock strategy, makes a mass production according to prediction, and keeps a certain inventory in the local plant. When the customer order arrives, the supplier makes a distribution to the location of customer straight from the local plant.
(5) VOP2-OPP3: the VOP of the supplier locates at the inventory management function of the customer, while the OPP locates at the supplier's local plant. The supplier adopts the make-to-stock strategy, but offers customer the service of inventory management, takes a mass production on the basis of the customer's inventory state, and does the supplementary service for the customer while the storage level of customer decreases to the order point.

Table 107.2 Combinations of VOP and OPP

		VOP1 Offer to purchasing	VOP2 Offer to inventory management	VOP3 Offer to planning and make	VOP4 Offer to designing and make
MTS	OPP1 (MTS, Local warehouse)	Mode1 (VOP1-OPP1)			
	OPP2 (MTS, Regional DC)	Mode2 (VOP1-OPP2)	Mode3 (VOP2-OPP2)		
	OPP3 (MTS, Plant)	Mode4 (VOP1-OPP3)	Mode5 (VOP2-OPP3)	Mode6 (VOP3-OPP3)	
ATO	OPP4 (ATO, Regional DC)	Mode7 (VOP1-OPP4)	Mode8 (VOP2-OPP4)		
	OPP5 (ATO, plant)	Mode9 (VOP1-OPP5)	Mode10 (VOP2-OPP5)	Mode11 (VOP3-OPP5)	
MTO	OPP6 (MTO, plant)	Mode12 (VOP1-OPP6)	Mode13 (VOP2-OPP6)	Mode14 (VOP3-OPP6)	
DTO	OPP7 (Design and make)		Mode15 (VOP2-OPP7)	Mode16 (VOP3-OPP7)	Mode17 (VOP4-OPP7)

(6) VOP3-OPP3: the VOP of the supplier locates at the production planning function of the customer, while the OPP locates at its local plant. The supplier adopts the make-to-stock strategy, offers customer the production planning service, and takes a mass production in accordance with the production planning of the customer, then starts the replenishment work for the customer in time.
(7) VOP1-OPP4: the VOP of the supplier locates at the purchasing function of the customer, while the OPP locates at the Regional DC. The supplier adopts the assemble-to-order strategy, produces of semi-finished product in large-scale, and keeps a certain level of storage at the Regional DC, then the finished goods are assembled for each arrived customer order. The Regional DC takes the responsibility of sending goods to the region of customer.
(8) VOP2-OPP4: the VOP of the supplier locates at the inventory management function of the customer, while the OPP locates at the Regional DC. The supplier adopts the assemble-to-order strategy, offers service of the inventory management, and makes an assign for the manufacturing of the semi-finished goods which will be delivered to the Regional DC. As soon as the inventory of customer is in line with the order point, the Regional DC takes charge of the distribution after final assembling.
(9) VOP1-OPP5: the VOP of the supplier locates at the purchasing function of the customer, while the OPP locates at its local plant. The supplier adopts the assemble-to-order strategy, produces semi-manufactured goods according to forecast, and stores a certain of them in the plant warehouse. After the arrival of orders, the plant will be responsible for the compositions delivery after the assembling.
(10) VOP2-OPP5: the VOP of the supplier locates at the inventory management function of the customer, while the OPP locates at its local plant. The supplier adopts the assemble-to-order strategy, does a support service for the customer's inventory management, and makes a plan for manufacturing the semi-finished goods. When the customer's inventory drops to the order point, the assembling work begins, and then the finished goods are delivered to the destination from the plant.
(11) VOP3-OPP5: the VOP of the supplier locates at the production planning function of the customer, while the OPP locates at its local plant. The supplier adopts the assemble-to-order strategy, stocks the semi-finished goods and renders a service of the production planning. The products will be assembled following from the relevant planning, and can be delivered from the plant to the customer for inventory replenishment directly.
(12) VOP1-OPP6: the VOP of the supplier locates at the purchasing function of the customer, while the OPP locates at its local plant. The supplier adopts the make-to-order strategy, does enough purchase of raw materials under forecast, and then begins the production in accord with customer orders arrived. The products are distributed to each customer from plant.
(13) VOP2-OPP6: the VOP of the supplier locates at the inventory management function of the customer, while the OPP locates at its local plant. The

supplier adopts the assemble-to-order strategy, gives assistance of the inventory management for customers, and begins to purchase raw materials based on the shared storage information. The producing program starts while the amount of inventory decreases to the order point, the manufacture-finished products will be sent out straightforward from the plant.

(14) VOP3-OPP6: the VOP of the supplier locates at the production planning function of the customer, while the OPP locates at its local plant. The supplier adopts the make-to-order strategy, and makes a production planning for customers. The procurement of raw material and the production are fulfilled in line with the customers' plan. Goods are also sent from plant after the production.

(15) VOP2-OPP7: the VOP of the supplier locates at the inventory management function of the customer, while the OPP locates at the local plant. However, the supplier adopts the design-to-order strategy, manages inventory for customer. Then the products are designed and produced based on the customers' inventory information and the order point. The supplier will transport goods from the plant to each customer when the productions are finished.

(16) VOP3-OPP7: the VOP of the supplier locates at the production planning function of the customer, while the OPP locates at the local plant. The supplier adopts the design-to-order strategy, offers production planning service to customers. But the goods are designed and manufactured in accordance with the customer's plan. Finally, the supplier sends goods from the plant to customers.

(17) VOP4-OPP7: the VOP of the supplier locates at the production designing function of the customer, while the OPP locates at its local plant. Both of them are at the most upstream of the chains. The supplier adopts the design-to-order strategy, and provides customers with product design service. They begin to cooperate with each other for the product design. According to the design, the supplier completes the tasks in design and production, and then sends goods to the customer.

107.5 Conclusions

The analyses in this paper concerning hybrid positing of VOP and OPP within the demand-supply chain lead to three main conclusions. First, it is important to realize that there are "new" value gains by simultaneously positioning these two points. Second, the customer involvement for such analysis is the most important element. Third, positioning requires a complex cost/benefit analyses of different parts. In closing, we would like to indicate that this process can be long and contain a high complexity but at the end improves the effectiveness of demand-supply chains.

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Chapter 108
Implementing Supply Chain Operation Reference (SCOR) Model in Manufacturing Firm of a Developing Country

Muhammad Salman, Syed Amir Iqbal and Rameez Khalid

Abstract In modern era where lean manufacturing has reached considerable level of perfection rather started following law of diminishing returns, supply chain performance becomes one of the key business success factors. Due to this fact, lot of work has been done on the development of supply chain performance measurement models and their implementation to improve overall supply chain performance. These models are balanced combination of business process re-engineering and efficient usage of information technology. There are several practical examples around the globe where firms got significant benefits by implementing these models but such models are not yet common in developing countries, instead several considerations are important if they are to be implemented there. This paper discusses the implementation of SCOR in a manufacturing firm in Pakistan along with the challenges faced during its implementation. The objective is to keep SCOR's efficiency as good as in the developed countries.

Keywords Aggregate planning · Business process reengineering (BPR) · SCOR framework · SCOR implementation · Supply chain performance management

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108.1 Introduction

Supply chain performance measurement and management has been one of the most discussed and drilled topics since its importance have been acknowledged. In their endeavor of building or rebuilding an efficient supply chain, top 60 companies of USA invested heavily on state of art technologies, human resource and infrastructure, but they did not get enough advantage due to inadequate performance measurement systems (Lee 2009). Supply chain performance is reflected in various reports of a company such as Balance sheets, P/L statements and even it may be gauged by the level of customers' satisfaction. Focus on supply chain performance is targeted to improve sales, return on investment, development and implementation of supply chain strategy and better utilization of information technology (IT) (Rosenbaum and Bolstorff 2003). Hence, in order to get competitive advantage, design and implementation of a well-structured supply chain performance management system plays a vital role (Chandran 2003).

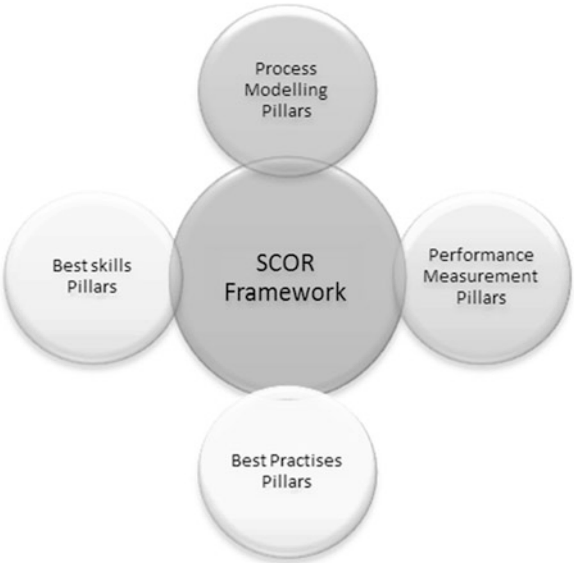
As the old saying goes, "you cannot manage what you cannot measure", the issue of performance measurement cannot be overemphasized (Ren et al. 2006). There are several models for the measurement of supply chain performance such as; Balanced Scorecard, Strategic Measurement Analysis and Reporting Technique (SMART) system, Performance Criteria system, Integrated Performance Measurement System Reference model (Ren et al. 2006), RosettaNet Standards and Reference models (Kirchmer 2004a). There are some shortcomings in these systems though, such as lack of relationship between performance measures, no clear distinction between operational and strategic KPIs, non-measurable data, etc. (S. C. Council 2010). All such issues are catered by a Supply Chain Operation Reference model (SCOR) (Ren et al. 2006). This paper discusses the issues to take care of while implementing SCOR in a manufacturing firm in Pakistan. This is of special interest that how it will work in ameliorating the supply chain practices of a Pakistani industry. Next section will present a short description of SCOR Model, its benefits and generic implementation steps. SCOR implementation issues relevant to Pakistan are presented in Sect. 108.3 while Sect. 108.4 will discuss the details of a SCOR implementation pilot project in a manufacturing firm. Conclusions and future perspectives are presented in the last section.

108.2 SCOR Model

SCOR model was developed by "Supply Chain Council" (SCC) in 1996. Supply Chain Council is a non-profit organization focused on research, application and advancement in supply chain management systems and practices (S. C. Council 2010).

The SCOR-model is a value chain business process framework intended to link benchmarks, technology, best practices, standardized metrics, and business

Fig. 108.1 Pillars of SCOR framework



processes directed to enhance supply chain performance (Gulledge et al. 2001). Major objectives of the model are to evaluate process efficiency, comparison of best practices with competitors, determination of benchmarks, competitive advantages, benchmarking and performance metrics, and finally the determination of appropriate software package (Stewart 1997).

SCOR Framework basically integrates the pillars shown in Fig. 108.1, in such a way so that supply chain excellence may be generated. According to SCOR model, all business activities are associated with one of the five Supply Chain processes; Plan, Source, Make, Deliver and Return.

SCOR provides a hierarchical framework for business process manifestation in terms of levels (up to 5). Each level provides the opportunity to model and refine the business processes at every stage. This hierarchical framework enables a company to visualize its supply chain and to improve its comprehension and integration of the business processes (Ren et al. 2006).

SCOR model provides performance metrics for each level which actually evaluates the performance of the chain and highlight areas for improvement (Schultz 2003). Performance measurement helps in identifying weak areas and hence best practices from all around the globe are replicated as per highlighted weaknesses. These practices may be part of Business Process Re-engineering (BPR), Lean Manufacturing, Six-Sigma, Theory-of-Constraints (TOC), and Balanced Scorecard. Value of a supply chain system is manifested by the output it generates such as costs, profits, inventories, customer services and assets (Lee 2002). SCOR implementation benefits are well explained by SCC among which reduction in order-cycle time (up to 60 %) and Inventory cost (70 %) are more embossed (Ralf et al. 1998). As the SCOR framework is applied more thoroughly and openly in companies, they will begin to reap long-term as well as short-term benefits that will eventually provide transformational change in how the business is managed, measured and controlled for achieving the strategic goals.

108.3 SCOR Implementation

Like all other change management projects, SCOR implementation has certain prerequisites regarding team building and, marked project phases and flow. For successful implementation, some other necessary factors such as strong supply chain background, rational thinking abilities, leadership, problem solving techniques, engineering approach and most importantly project management skills are supposed to be there in the SCOR implementation project team.

SCOR implementation phases address the enterprise level issues down to the material flow level (Swartwood 2003), as shown in Table 108.1 that defines the five phases of SCOR implementation (Kirchmer 2004b). Cross functional projects such as SCOR implementation require individuals from different functions of the company which is usually resisted as the biggest barrier to change management (Sheoran et al. 2003). SCOR implementation spans around development of AS-IS and TO-BE models which goes through several stages. SCOR benefits are calculated by comparing AS-IS and TO-BE productivity summaries. All improvements are then documented showing how business processes should be. As per SCOR implementation phases, this is the end but actually it is the beginning of something which is endless in nature (Rosenbaum and Bolstorff 2003).

108.4 SCOR Implementation Issues in Pakistan

Pakistan is a developing country with negative trade balance and a weak currency. In Pakistan, Supply chain strategy is strongly affected by issues emerging from weak infrastructure and lower literacy rate (Kaminsky et al. 2010). Enterprise Resource Planning (ERP) software implementation has matured a bit in Pakistan but still with some loop holes. Most significant issue in ERP implementation is the modification of the ERP system as per past practices; instead of learning to analyze data and information from built-in standard practices and features.

Similarly, in case of SCOR implementation, issues of tailoring the system will be one of the biggest problems. Implementation of best practices will require comprehensive training and counseling to make the team understand and plan for future. Finding Evangelist (SCOR Specialist) is very difficult in Pakistani environment as there is very little awareness regarding SCOR model.

Documentation of AS-IS model is also one the point of concern because of unspoken or unwritten standards and procedures which are followed on daily basis. People are very reluctant to document them as well.

Table 108.1 SCOR implementation stages

Stage	Description	Challenges	Tools
Education	Create awareness regarding importance of supply chain performance in overall operations	Resistance against change management	Trainings, workshops
Identification of opportunity	Appropriate competitive analysis to identify opportunity for improvement	Management agreement regarding benefits to be achieved from the project	Business context summary, supply chain definition Matrix, project charter
Analyze basis of Competition	Identification of critical success factors, development of performance metrics, benchmarking	Bringing agreement between all stakeholders on KPIS and benchmarks	Gap analysis between benchmarks and actual KPIs
Design material flow	Development of AS-IS model for material flow which provides basis for TO-BE model	Lack of ownership on analysis and data presented	AS-IS and TO-BE Model, Data Flow diagram, process mapping, and logistic networks, fishbone, brain storming, disconnect analysis
Work and information flow analysis and design	Information flow analysis and design begin with the complete tracking of all transaction for all levels up to their completion	Keeping improvement process on going	SWIM diagram, AS-IS and TO-BE productivity summaries

In achieving supply chain excellence, role of vendors is of vital importance. In Pakistan, most of the local vendors even for multinational companies (MNCs) are cottage industry based entities where IT integration is almost a dream. Roads, Railways and even Air channels are inefficient in many ways which ultimately hits supply chain performance.

Energy shortfall is another bitter truth which does not let suppliers to work efficiently. Increased utility prices are also hitting reducing supplier margins. Law and order situation is very volatile in Pakistan. In order to cope up with issues of strikes, excess inventories are kept which results in the blocking of large working capital and higher inventory days.

Today when world has recognized the importance of supply chain, still extensive focus is required on education and training to bring awareness in Pakistan. Supply chain is still considered as a general service practice whereas world is taking it as major driving force of the organization. Due to this fact, reluctance was faced when ERP was emerging in Pakistan, many industries considered it as an expense with negative return. This paper is one of the pioneer studies performed to experiment and disseminate the benefits of assessing and enhancing the performance of supply chain in Pakistan using SCOR model.

108.5 SCOR Implementation Pilot Project

A large manufacturing firm from private sector was selected for SCOR implementation pilot project. Implementation is focused on BPR and adaptation of best practices. Implementation team placed the IT infrastructure as currently out of scope. Name of the industry is not disclosed due to confidentiality agreement between company and authors.

The project started with education and training. Number of sessions were delivered to bring awareness about SCOR model and bring ownership for it, as it is not just about software and hardware rather it is a complete change in perspectives, job responsibilities, goals and working styles (Laudon and Laudon 2006).

After several sessions and data analysis, three major problems were selected for analysis and improvement:

- Reduction in Import Procurement cycle
- Dead SKU Stocks liquidation
- Physical Material Replenishment

Detailed working on Import procurement cycle has been done and implemented with good results. This paper presents the first problem with its resolution. Other two problems are kept as future working areas.

108.5.1 Problem Description

In large scale manufacturing organizations of developing countries, there is a large percentage contribution of imported materials both in terms of value and quantity. Also, most of the firms spend 50 % of their resources in purchasing (Heizer et al. 2008). Subject Industry is one of the leading manufacturers in Pakistan. Its imported components with huge lead times are the basis of soft and hard varieties of all Stock Keeping Units (SKUs). This makes almost impossible to bring agility in supply chain with minimum inventory cost. Moreover dynamics of Pakistani environment demands high flexibility in product mix as per situation and season (Lee 1992).

Import procurement cycle is run once a month in which imported materials are procured on N + 4 month cycle i.e. for example material for October production will be ordered in June. By thumb rule, order processing, manufacturing, shipment and, clearance and delivery takes 1 month each. It follows general ordering rule which determines quantity and timing of ordering, as also defined by Taha (2008).

This is quite safe method for ordering with respect to stock-outs but it becomes big barrier against supply chain responsiveness and agility. In this era of competition, it is very import to be agile enough to respond against quick market trends and competitors' moves (Chopra and Meindl 2010). Moreover, due to large pipeline inventory and in-transit orders, inventory pile-ups are also one of the major threats (Tersine 1994). This makes the supply chain neither responsive nor efficient.

108.5.2 AS-IS Cycle

In this industry, aggregate planning is driven by a Sales Stock file which consists of all major information (such as sales forecast, production plans, capacity, inventory levels, actual sales and production) necessary to plan production. In import procurement cycle, major functions that play their roles are Sales, Marketing, Manufacturing, Production planning and Imports procurement. Figure 108.2 describes some of the major sub-activities which are necessary to complete this cycle.

In first phase, actual sales and production data are collected from sales and manufacturing respectively, and updated in the sales stock file. Marketing department provides sales forecast for N + 4th month. Marketing department is restricted not to bring any change in N + 1, N + 2 and N + 3, months due to the lead time constraint.

Planning department evaluates the forecast and balances the capacity as per forecast. After this activity MRP is executed and orders are calculated which are provided to imports procurement department which is responsible for negotiations and documentations (Supply Chain Council 2006).

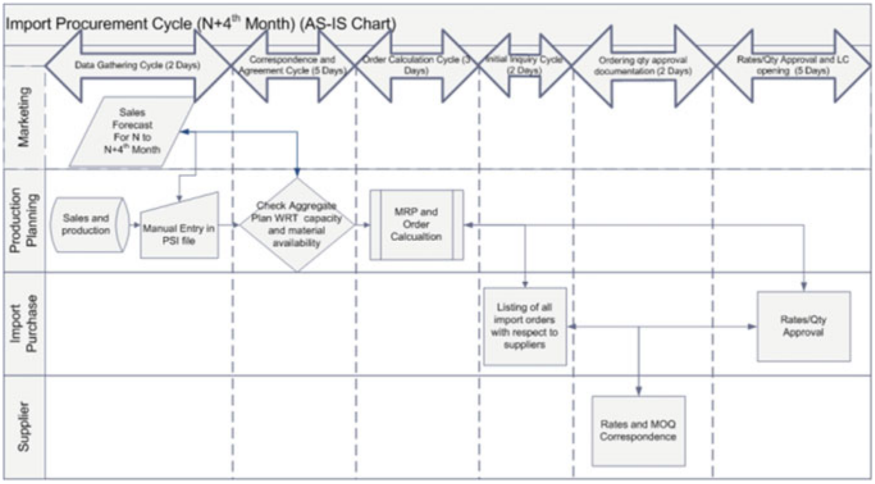


Fig. 108.2 AS-IS model for import procurement cycle

108.5.3 TO-BE Model

After analysis it was found that the complete import procurement cycle takes nineteen (19) days to complete, which is definitely a very long time. Main bottleneck is the agreement between the stakeholders over the coming month's forecast. It usually takes 5 days on the average, sometimes even more than that. In first phase, import purchasing cycle is modeled using SCOR standard processes as shown in Fig. 108.3 and inefficiencies are identified.

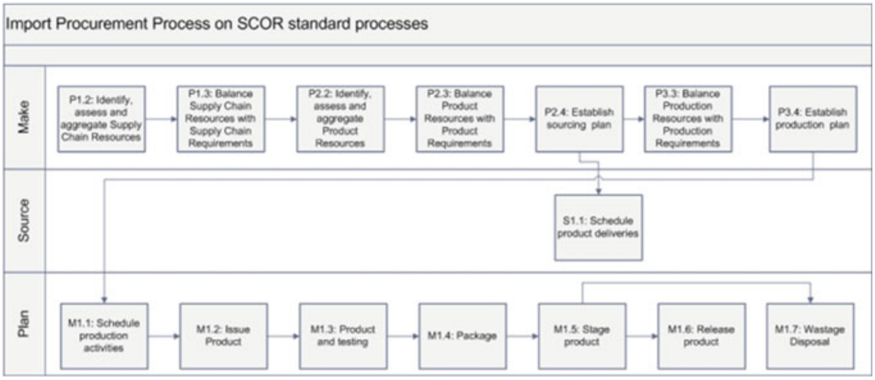


Fig. 108.3 TO-BE model in SCOR standard processes

108.5.4 Issues in AS-IS Model

Issues identified in AS-IS model are: Ordering cycle takes 19 days which is very long cycle; Forecast finalization and mutual agreement between Sales/Marketing and Planning departments require substantial amount of time; in case of excess sales, there is no room to accommodate before 3 months; similarly phase out of SKUs also require 4 months.

108.5.5 Initiatives

Two major steps were taken to improve the cycle time. In order to save the time lost in agreement of stakeholders, Sales was asked to provide estimated sales on the basis of actual sold units till 20th of every month. This gave a near exact estimate of closing sales on the basis of which, N + 4th month's forecast could be determined. Agreement activity was almost done before the start of month which gave straight reduction of agreement time. Secondly, forecast of next twelve months is provided to the suppliers so that suppliers remain prepared for new orders.

108.5.6 Results

SCOR framework helped the company in achieving these results: 9 days (47 %) were saved from ordering cycle due to implementation of calculations based on estimated sales; Estimated sales also ring alarms in case of slow moving SKUs which enables an early information to supplier in case of order deferral or reduction as well; Further improvement in it can bring ordering cycle down from N + 4 to N + 3. Secondly due to provision of 12 months forecast, suppliers planned in advance for their raw material, this allowed the company to increase up to 10 % overall production and 22 % in one SKU in N + 1, N + 2 and N + 3 which were taken as frozen previously.

108.6 Conclusions

This paper presents the salient features of SCOR framework along with several critical success factors for effectively using SCOR which shows importance of performance measurement in supply chain management.

SCOR implementation details are then explained along with its major phases. Barriers in the implementation of SCOR model in Pakistan are also discussed among which major issues are low literacy rate, tailoring of IT solutions, uncertainties in law and order situation, fluctuations in utility charges and ultimately raw material cost, scarcity of energy, and lack of awareness.

In the end Import procurement cycle time of a famous manufacturing company in Pakistan was presented and the problem was analyzed using SCOR method which revealed the fact that even if the SCOR implementation process is followed with any existing IT solution, it will result in considerable improvement. Results were an eye-opener for the company as it saved 47 % (9 out of 19 days) time in the import procurement cycle. Moreover, increase up to 10 % in overall production of fixed order months was achieved. During identification of opportunity phase, three major problems were highlighted out of which only one, i.e. Import procurement cycle was discussed. Other two problems which are Physical material replenishment and dead SKU utilization will be covered in future.

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Chapter 109
Information Sharing of Jointly Managed Inventory (JMI) Under the Environment of Supply Chain Management

Xing-dong Li and Li-fen Fang

Abstract This paper researches information sharing problems of Jointly Managed Inventory under the environment of supply chain management, choosing the Jointly Managed Inventory based on coordinate center as research object. Firstly, this paper deeply analyses two existing problems of information sharing in the Jointly Managed Inventory system, that is the information asymmetry between member enterprises in the JMI and the information variation of the supply chain—"The bullwhip effect". Then this paper discusses the implementation of the sharing of information in the JMI from three aspects: technical support of information sharing, stimulus measures, and strengthening information sharing measures. Finally, in order to validate the practicality of information sharing, this paper discusses the value of information sharing to the Jointly Managed Inventory and the entire supply chain system.

Keywords Information sharing · Jointly managed inventory · Management · Supply chain

109.1 Introduction

Along with the rapid development of market economy, the traditional and individual competition between enterprises has transformed into the competition between supply chains, and the overall performance of supply chain directly affects the economic efficiency of member enterprises within it (Li 2008; Liu 2011b; Yun 2008). Supply chain inventory management as an important part of supply chain management is the significant means to pursue the low cost and high

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benefit (Cui 2007; Liu 2007). Jointly Managed Inventory (JMI) developing on the basis of Vendor Managed Inventory (VMI) is an inventory management mode in which the upstream and downstream enterprises share the risk and balance authority and responsibility. JMI emphasizes that each node enterprise in the supply chain participates in setting inventory plans at the same time, so that each inventory manager in the supply chain process makes consideration from mutual coordination, and keeps the demand forecast made by inventory managers of each node in the supply chain accordant (Li 2006; Liang 2005; Zhu 2004). Thus to realize information sharing in the JMI is of vital importance. But information sharing in the JMI is not fully achieved. So the research of information Sharing of Jointly Managed Inventory is important to better implement JMI in the supply chain (Bowersox and Closs 1996; Cheung 2002; Dai 2007).

109.2 The Analysis of Information Problems in the JMI

JMI is inspired by the function of regional distribution center, making new development and reconstruction of the current supply chain inventory management mode, and then put forward the new supply chain inventory management mode—jointly managed inventory system based on coordination center, the system structure is shown in Fig. 109.1 (Liu 2011a; Yan 2002; Zhu and Bao 2008). JMI embodies a new enterprises cooperative relationship of the strategic supplier alliance. It emphasizes on the joint management of inventory by node enterprises, the most important thing is communication of information between enterprises, and incorrect transmission of information would lead directly to JMI display its function incompletely (Ding and Zhang 2000; Yan and Lu 2003). In the actual JMI application process, information sharing problems are reflected in the following (Liu 2010; Wang et al. 2011), as shown in Table 109.1.

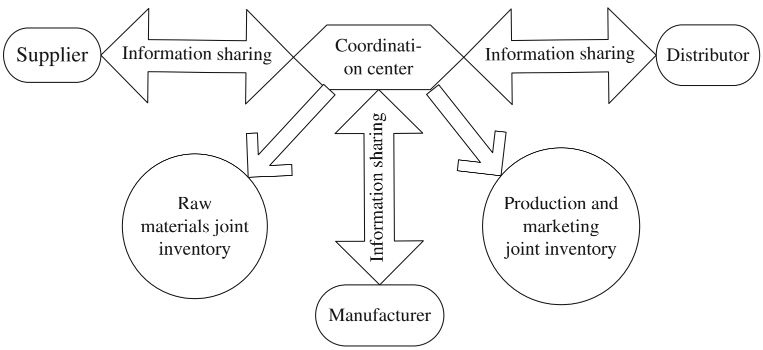


Fig. 109.1 Jointly managed inventory system based on coordination center

Table 109.1 Information sharing problems

Information sharing problems	Causes
The information asymmetry	1. The node enterprise of supply chain pursues the maximization of its own benefit
	2. There are problems of information sharing standards in the supply chain
	3. Information management level in the node enterprises of supply chain is uneven
The information variation	1. The demand forecast correction
	2. The decision-making of order quantity
	3. Price fluctuation
	4. Shortage game
	5. The imbalance of inventory responsibility
	6. Coping with the environment changes

109.2.1 The Information Asymmetry Between Member Enterprises in the JMI

The cooperation between enterprises in market economy is widespread, and JMI is to minimize inventory cost and increase economic benefit, but information asymmetry seriously affects this partnership. The principal-agent relationship directly reflects the influence of information asymmetry to cooperation between enterprises. In general, the principal is often more easily in a bad position than the agent for the information asymmetry (Guo 2009). In the whole supply chain environment, manufacturer often plays the role of the principal and supplier is the agent. The agent tends to get more profit from partners by the means of increasing information asymmetry. There are two kinds of information asymmetry. One is time asymmetry, from this perspective, asymmetry may occur before a cooperation agreement have reached, and is also likely to occur after a cooperation agreement have reached, which respectively called prior asymmetry and ex-post asymmetry. The other is the content asymmetry of information, from this perspective, asymmetric information may be both personnel's behavior or knowledge information, which respectively called behavior hiding and information hiding. And the causes of enterprise information asymmetry mainly embody in the following respects.

(1) The node enterprise of supply chain pursues the maximization of its own benefit.

The node enterprises of supply chain are the interests competitors, and no matter choosing Jointly Managed Inventory or independently managed inventory, node enterprises target maximization of their own interests, information sharing often need to cost, at the same time the distribution of information sharing benefits is non uniform, and enterprises will produce negative attitude of information sharing. In the information sharing process, in order to prevent business secrets of node enterprises like the core technology, purchase, sales, and finance information from disclosure to weaken the core competitive ability, and prevent appearing the unprofitable phenomenon or cost increase of information management. Cooperative enterprises are subjectively lack of information sharing enthusiasm, mainly manifesting in the following: (a) Node enterprises conceal information or provide incomplete information; (b) The conflicts of interests between node enterprises affects information sharing; (c) Higher operating costs lead to the low degree of information sharing.

(2) There are problems of information sharing standards in the supply chain.
The standardization of information sharing is the prerequisites of supply chain information sharing, is the relevant specific standards about information collection and processing, storage, transportation and use. Only each node enterprise in the supply chain shares information in accordance with the unified information standards can the information effectively integrate, and the correctness of information transfer, storage and use be ensured.
Currently, China's supply chain management is in a serious lack of standardization of information sharing, many enterprises even cannot make unified standards about their own internal technical standards of product information such as product coding and management coding, this inconsistent standards of information sharing in enterprise interior leads directly that the node enterprises cannot proceed collection, use and dealing with their own information and information transfer with other enterprises; At the same time, most industries fail to achieve the unity of information standards and service standards, which causes node enterprises of different industries in the supply chain are hard to find unify standards, and there is no information standardization means to support. These unfavorable factors objectively increase the difficulty for realizing the sharing of information fully.

(3) Information management level in the node enterprises of supply chain is uneven.
Information sharing requires enterprises to perfect the internal information management, and establish or reconstruct internal information system according to the requirements of information management in the supply chain, realizing information collection, processing and transfer standardization, if the internal information flow of one node enterprise is blocked, it will affect the effect of JMI, and also affect on related enterprises of supply chain, leading supply chain efficiency or competitive to be down. But the information management level of node enterprises of supply chain is uneven, and information technology and modernization level of node enterprises is so differ that cannot meet the basic requirements of the supply chain information management, leading to information flow be blocked and information sharing be obstructed. The irregularity of information management level is shown as following: (a) Information management within some node enterprises is not standard; (b) The modernization technical level of some enterprises is insufficient; (c) The informationalized level of some node enterprises is not high.

109.2.2 The Information Variation of the Supply Chain: "The bullwhip effect"

"The bullwhip effect", also known as demand amplification effect, as shown in Fig. 109.2, is a description about the demand information distortion in the supply chain transmission by a famous American expert—Professor Li (2009). This demand amplification effect of information can be attributed to the sharing of information incompletely. Procter found the development law of "the bullwhip effect" in research of "diaper" market demand. Node enterprises in the supply chain make product supply decision only according to the demand information provided by adjacent downstream node enterprises, causing demand information to distort in the process of transmission along the supply chain, the information variation in the supply chain gradually upload, to the suppliers at end of the supply chain, demand information obtained by suppliers has very big deviation with the actual requirements of terminal consumers. Because of this demand information variation, the inventory level of suppliers is higher than the demand of downstream distributors, causing the inventory level of node enterprises to increase, and increasing inventory cost and operation cost, which eventually lead to the production, supply, and marketing chaos. In general, the main causes of "The bullwhip effect" has six aspects, that is, the demand forecast correction, the decision-making of order quantity, price fluctuation, shortage game, the imbalance of inventory responsibility and coping with the environment changes, the six aspects can be summarized as information sharing problems of supply chain (Li 2009).

109.3 The Implementation of Information Sharing in the JMI

109.3.1 Technical Support of Information Sharing

(1) *Peer-to-Peer Information Sharing Mode*

Peer-to-peer mode of information sharing is that partners share information through the information system, one party of cooperation enterprises participated

Fig. 109.2 "The bullwhip effect" sketch map

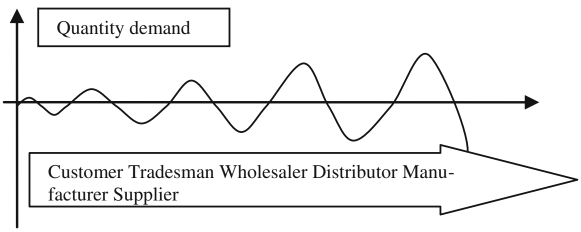
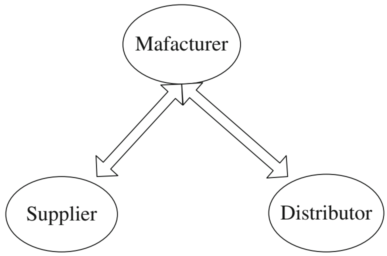


Fig. 109.3 Peer-to-peer mode of information sharing

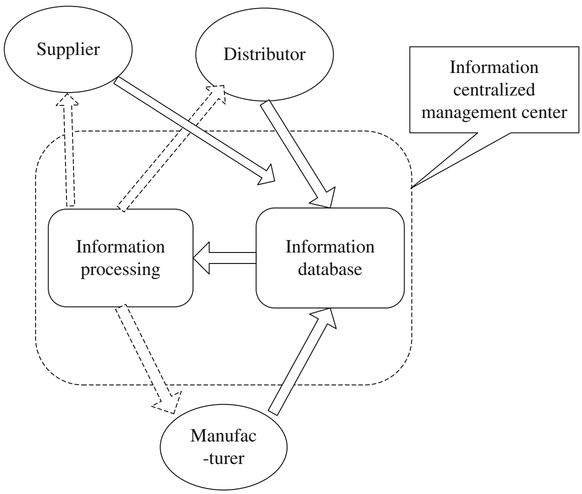


in information sharing store information datum provided by the other party to information database, both cooperation parties communicate and exchange information directly without the third party. The transmission of information is done in pairs, and the same information may be transferred between two different databases, namely the sharing of information is done directly by two enterprises, as shown in Fig. 109.3. In this information sharing mode, peer-to-peer sharing mode can be divided into EDI mode and data interface mode according to the information technology. The mode is shown in Fig. 109.3.

(2) *Centralized Management Mode of Information*

Centralized management mode of information gathers information data to information database in the information centralized management center, and then provides useful information after information processing, as shown in Fig. 109.4. The database of information management center is a public database, each enterprise access to it according to its respective limits of authority, enterprises complete information sharing through the input and output information. The third party mode and information platform are two main kinds. The third party mode is that the third party enterprise provides public database services, collecting and processing relevant

Fig. 109.4 Centralized management mode of information



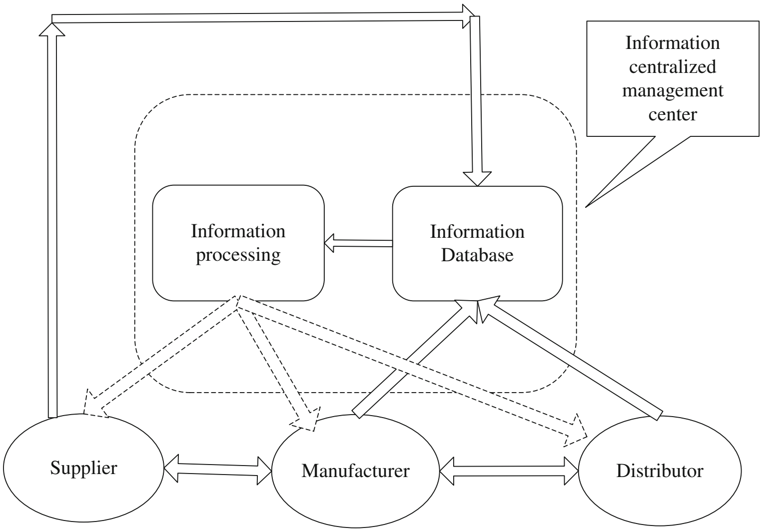


Fig. 109.5 Comprehensive information sharing mode

information of the supply chain for the supply chain members, but the third party enterprise can also gather information from outside, and process this information, therefore, the authenticity of the datum cannot be guaranteed. Information platform mode is that using information platform to manage public database, internal information database of each enterprise can complete information transmission with information platform by computer, service is responsible for the management and maintenance of the information platform function modules, and don't participate in the information service, information authenticity would be guaranteed.

(3) *Comprehensive Information Sharing Mode*

Comprehensive information sharing mode is a comprehensive mode of peer-to-peer information sharing mode and centralized management mode of information, adopting different ways according to the actual situation, and constructing in a subject framework of information platform. Based on the actual needs of information, adopting reasonable information sharing mode, which can be better to meet needs of information sharing in each area and also accord with the actual situation. The mode is shown in Fig. 109.5.

109.3.2 Stimulus Measures of Information Sharing

There many kinds of stimulus measures to strengthen information sharing, and choosing the right stimulus measures according to the actual need is critical a success factor.

(1) Price stimulus. In the supply chain, interest distribution and lose sharing of the member enterprises mainly embody in the price, price control can effectively balance the income and lose, and can also encourage enterprises more actively participate in information sharing.
(2) Order stimulus. Getting a big order through the information sharing is enough incentive for the member enterprises, generally speaking, manufacturers having many suppliers can inspire suppliers to participate in information sharing through the order stimulus.
(3) Goodwill stimulus. A very good reputation is beneficial for enterprises to get the public recognition and trust in the process of market sale, so the goodwill stimulus is an important kind of measures and provides intangible assets.
(4) Information stimulus. Nowadays, information is money, so information exchange is also good means of deal, getting more information means that the enterprise has more opportunities, so as to acquire stimulus.
(5) Elimination stimulus. Elimination stimulus is a kind of crisis stimulus, making partners have a sense of elimination urgency, thereby, partners would actively participate in the information sharing to avoid eliminating.
(6) The stimulus of new product and technology developing. The common development and investment of new products mean opening up and developing market together, and is also a positive incentive for the partners.

109.3.3 Strengthen Information Sharing Measures

(1) Redistribution mechanism of interest. In the JMI, the performance of supply chain will be improved after the sharing of information, only reasonably dealing with interest distribution can better stimulate partners to consciously participate in information sharing. Enterprises always pursue their own interests, and if the benefit is increasing, the node enterprises will be actively involved in information sharing.
(2) Making standards of information sharing. The enterprises involve in information sharing according to the certain standards, which can make enterprises provide information with no choice, and ensure the authenticity and integrity of information, so as to improve the effectiveness of the information sharing and get the maximum value of the information.
(3) Shortening lead time. Shortening lead time of tradesman is beneficial to the effective transmission of information to manufacturers, promoting distribution and sharing of information, and it is helpful to reduce the overall average of inventory.
(4) Establishing and perfecting the supervision and evaluation system. Designing evaluation system for the enterprises that don't consciously participate in the information sharing and regularly making assess to find the existing problems is necessary. Of course under the premise of mutual acceptance, tough measures are more conducive to effective implementation of information sharing.

(5) Overcoming cultural differences. In the JMI, the cooperative enterprises often have differences of region and language, under the different culture background, the same information may have different definitions, so enterprises should remove these cultural differences by strengthening the communication to realize the fusion and consensus of cultures in different enterprises.

109.4 The Value of Information Sharing in the JMI

In the supply chain management, the value of information sharing embodies in many aspects, the standards of measure also has a lot. And the information sharing value of JMI mode is much more distinct and intuitional under the environment of supply chain.

(1) Increasing the information transparency and reducing the information asymmetry between enterprises. In the JMI, the realization of information sharing by node enterprises of the supply chain can effectively decrease various uncertainties of the enterprise exterior, and at the same time integrating enterprise information through the implementation of ERP system or the MIS system of enterprise exterior to comprehensively reduce negative effects of all sorts of uncertain information inside and outside enterprise.
(2) Eliminating the negative effect of "The bullwhip effect" and reducing inventory to increase the economic efficiency of enterprises. The most direct consequence of "The bullwhip effect" is that goods accumulation is at all levels of the supply chain, and causing serious waste of resources. In recent years, a large number of scholars have participated in researching governance measures of "the bullwhip effect", and information sharing is one of the most effective ways. In the traditional information environment, the supply–demand relation is drove by the orders, enterprises give priority to their own goals, and they independently take inventory control strategy, and now supply and demand sides implement JMI on the premise of information sharing, which greatly weaken the influence of "The bullwhip effect" to the supply chain.
(3) Maximizing the value of information is beneficial to the increase of the value chain. The market economy of "cloud era" should make full use of the clouds information, dredging information circulation channel, expanding information source, ensuring that the value of information is maximum. The value of information is reflected in its utilization efficiency and effectiveness, and how to transform information into benefit is the key to add value of the value chain in supply chain management, and smooth flow and effective use of information is also very important to increase economic benefit of the supply chain.
(4) Strengthen the alliance cooperation of enterprises to realize the true sense of JMI. JMI is on the basis of information sharing, node enterprises of the supply chain constitute enterprise alliance, and forming integrated operation and management of supply chain inventory. The information exchange and sharing

of the node enterprises participating in cooperation are the premise of effective operation, only on the premise of information interchange can enterprises increase mutual benefit. Then node enterprises would reduce unnecessary care and consciously participate in cooperation alliance, fully sharing and integrating information to make the efficiency of whole alliance maximum.

109.5 Conclusion

According to the research of information sharing problems of Jointly Managed Inventory, we can conclude that solve information sharing problems may from the follow programs:

(1) Realizing the causes of Information sharing problems, and testing reasons combined with the actual work.
(2) Choosing the appropriate technical support of information sharing, in other words, select the right information sharing Mode.
(3) Correctly applicating stimulus measures of information sharing.
(4) Choosing right measures to strengthen information sharing.
(5) Assess the value of Information Sharing in the JMI to decide whether to further improve information sharing.

Information sharing is important means to improve the level of supply chain management, and to increase the profit of supply chain system; it is the key to display function of the JMI. JMI emphasizes the authenticity and integrity of information sharing among node enterprises, emphasizing the breadth and width of information sharing, in does not affect the enterprise core confidential. On condition that enterprises protect core secrets, enterprises should dredge information circulation channel and grasp the validity of the information, to achieve fully information sharing and ensure the effective implementation and maximum performance of the JMI.

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Chapter 110
Inventory Control of Dangerous Goods in Materials Reserve for Circulation

Na Zhang, Hui-zhen Kang, Jia Liu and Li-yun Zhang

Abstract The dangerous goods play an important role in the control of the materials reserve for circulation, therefore separate management programs are needed. At present, military for dangerous goods logistics research is still in its infancy, especially less storage management studies. In this essay we establish a working capital reserve model for the different categories of dangerous goods materials, providing the basis for the storage management of dangerous goods.

Keywords Dangerous goods · Inventory model · Materials reserve for circulation · Suitability of mass storage

110.1 Introduction

The materials reserve for circulation is storage for the protection of daily uninterrupted supply by the supplies department (Chinese Military Encyclopedia 2008).When convergence materials purchase interval or in case of additional requirements and delivery delaying, the materials reserve for circulation can meet the daily material needs of users. The special physical and chemical properties of dangerous goods, decided to it unlike supplies' requirements of the logistics management (Fan and Hong). Not only in the economic management of large investment, but also significant security responsibilities (Clay Whybark 2007). The dangerous goods of too much inventory will give the military logistics brings great financial pressure and safety pressure. Considering the balance of economic and military benefits, not all dangerous goods are fit for real storage. Considering the scale of real storage of dangerous goods from the angle of suitability of mass storage, we can draw a more targeted storage management program.

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110.2 Inventory Model of the Materials Reserve for Circulation

110.2.1 The Analysis of Factors Affecting the Storage of Dangerous Goods

Dangerous goods are a special class of materials. There are three aspects affecting the real storage management:

Importance: Indicates to material on military support important degree. It is an indicator to measure whether it allows out of stock and plays a key role in emergency operations (Joint Publication 2001). Determine the importance of the materials on military Dangerous Goods materials classified management has an important significance. Importance of the greater, the greater the managerial inputs, Event of shortages, the higher the price paid, or even difficult to measure with economic price. The greater of this index value, the more adaptation to the physical storage.

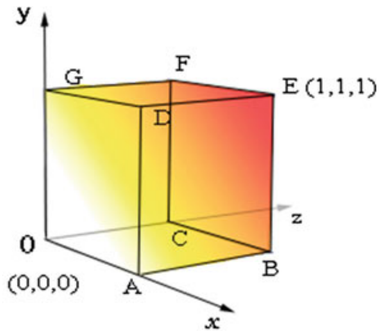
Response time: it is the entire during from the time users apply to the time they get the required materials (Shang 2009). It includes the preparing time of logistics center setting materials, as well as packaging, transportation, till the entire distribution process is completed. It is the whole time needed for the user to wait from the issue needs to eventually get the kind of materials. Burdens to emergency action will be added if logistic time lasts too long. So the longer the response time is, the more adaptation to the physical storage is necessary.

Physical and chemical characteristics: Physical and chemical characteristics of the materials determine its safety factor (Cao 2010). The lower safety factor is, the higher management costs will be in storage aspects, as well as greater responsibility for security of the warehouse. Thus it is fit for physical storage if physical and chemical characteristics are rather stable.

Using X, y, Z axis respectively represent the three major factors which affect of the dangerous goods physical storage. The x-axis indicates the importance, the y-axis represents the response time, the z-axis represents the physical and chemical properties, [0, 1] interval value representing the degree of Influencing factors. Get the following cube graph, as show in Fig. 110.1. O is the origin, the coordinate (0, 0, 0), said value of the three elements to the minimum at this point; Point E is the furthest point from the origin, the coordinate (1, 1, 1), said value of the three elements to the maximum at this point, that means the most important response to the longest, most stable physical and chemical properties.

The Materials need a large amount of reserves, which have high military value, and timeliness of emergency, long production cycle, wartime difficult preparations for the supplies. Materials of high-risk, high storage requirements, the corresponding big economic and personal investment, responsibility for security, this type of material needs less storage. Considering the scale of real storage of dangerous goods from the angle of suitability of mass storage, it is fit for physical

Fig. 110.1 The need for physical storage necessity



storage if the degree of importance and a long time to respond and the physical and chemical characteristics are rather stable. Show in Fig. 110.1: The nearly far point E, the greater the degree of the deeper the color, the need for physical storage necessity, conversely the physical storage is not necessary.

In summary, different material characteristics need different inventory models (Trevor and Christopher 2005). These can be divided into two types.

110.2.2 Inventory Model of Type I

The materials which have any one of these conditions—the degree of importance or a long time to respond in line are not allowed out of stock. In the development of the inventory amount of time, we should consider not only the economic costs, but also the continuous of supply.

The model assumptions are:

① As a daily consumption of materials, in the initial stage the demand for fixed, materials can be seen as a uniform and continuous consumption(Xun et al. 2009; Deng et al. 2010; Kao and Hsu 2002).However when the inventory quantity decreased to a certain level, the allotment level changes so does the number of allotment.

Therefore, the demand of materials per unit time conform function R = f (t), which is a piecewise function determined by the inventory and changed over time.

② ‘t’ is the lead time, which is from requirements to the material allotted, the whole process needs.

③ One-off to replenish stocks, Supplement the number of Q,

④ When the stock falls below the minimum turnover of inventory, start ordering.

The Inventory curve as shown in Fig. 110.2:

Q—Each order quantity;

T—Order cycle;

C—Material unit price;

C_1—Storage management costs per unit time per unit of goods;

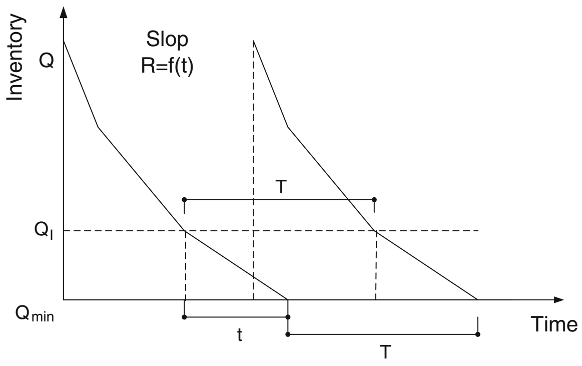


Fig. 110.2 The Inventory Curve of Type I

C_2—Order to prepare cost;

Demand rate: $R = f(t) = \begin{cases} R_1 & 0 \sim t_1 \\ R_2 & t_0 \sim t_2 \\ R_3 & t_2 \sim t_3 \end{cases}$

$t_1 = \frac{Q - Q_1}{R_1}$; $t_2 = \frac{Q_I - Q_1}{R_2}$; $t_3 = \frac{Q_I}{R_3}$

The number of average inventory in the time "t":

$$\frac{1}{t}\int_0^t RTdT = \frac{1}{2}RT = \frac{1}{2}(R_1t_1 + R_2t_2 + R_3t_3)$$

The total average cost in the time "t":

$$C(T) = \frac{C_2}{T} + C(\frac{R_1 + R_2 + R_3}{3}) + \frac{1}{2}C_1(R_1t_1 + R_2t_2 + R_3t_3)$$

For simplicity of calculation process, simplify the needs of the three time periods for the average: $R = \frac{R_1 + R_2 + R_3}{3}$;

Three-time stage $t_1 + t_2 + t_3 = T$.

That is a complete purchase cycle. On type derivation:

$$\frac{dc(T)}{dT} = -\frac{C_2}{T^2} + \frac{1}{2}C_1R = 0$$

$$T^* = \sqrt{\frac{2c_2}{c_1R}}$$

$\frac{d^2c(T)}{dT^2} = \frac{2C_2}{T^3} > 0$, Every T time ordering time, can make c(T) minimum.

Total orders: $Q^* = RT^* = \sqrt{\frac{2c_2R}{c_1}}$

Minimum turnover of inventory: $Q_I = R_3t$

It can be seen from the above results, the duration of preparatory materials used which will affect the inventory number. When the response time is very short, and even doesn't exist, the minimum turnover of inventory without reserve.

110.2.3 Inventory Model of Type II

This part of materials that have certain importance and response from the proposed requirements to the entire waiting time is very short, we think mainly about the economic cost when considering this part of the inventory model. In order to balance economic efficiency and logistic safeguard effect, this type of material is allowed to happen to be short-term shortages. So the assumptions are:

① The initial storage capacity is s, which meets the needs of the time t_1;

② The average storage is 1/2S in the t_1 time, within the time (t_1, t) stored as 0;

③ With the reduction in the number allotted level changes the value of R changes, and the allotted amount is change too (Zhao and Lan 2011). Therefore, the demand per unit time for the function is R = f(t). It is determined by the inventory over time piecewise function (Li et al. 2006; Liu and Chen 2005).

The Inventory curve as shown in Fig. 110.3:

C_1—Storage management costs per unit time per unit of goods;

C_2—Order to prepare cost;

C_3—Unit time out of stock losses;

demand rate: $R = \begin{cases} R_1 & s \sim q_1 \\ R_2 & q_1 \sim q_2 \\ R_3 & q_2 \sim 0 \end{cases}$;

Average demand rate: $R' = \frac{R_1+R_2+R_3}{3}$

Average shortage amount: $\frac{1}{2}R_3(t-t_1)$, $t_1 = \frac{s}{R'}$

Storage costs in t time: $C_1\frac{1}{2}st_1 = \frac{1}{2}C_1\frac{s^2}{R'}$ out of stock losses in t time: $C_3\frac{1}{2}R'(t-t_1)^2 = \frac{1}{2}C_3R'(t-\frac{s}{R'})^2$

The total cost of the unit of time

$C(t, s) = \frac{1}{t}\left[\frac{1}{2}C_3R'(t-\frac{s}{R'})^2 + \frac{1}{2}C_1\frac{s^2}{R'} + C_2\right]$

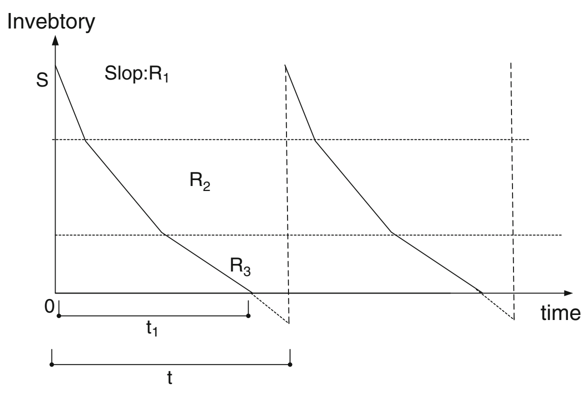


Fig. 110.3 The Inventory Curve of Type II

$$\frac{\partial C}{\partial s} = \frac{1}{t}[C_3 R'(t - \frac{s}{R'})(-\frac{1}{R'}) + C_1 \frac{S}{R'}]$$
$$= \frac{1}{t}[C_3(\frac{s}{R'} - t) + C_1 \frac{S}{R'}] = 0$$

$$s = \frac{R' C_3 t}{C_1 + C_3}$$

$$\frac{\partial C}{\partial t} = -\frac{1}{t^2}[\frac{1}{2} C_3 R'(t - \frac{s}{R'})^2 + \frac{1}{2} C_1 \frac{s^2}{R'} + C_1] + C_3 R' - \frac{C_3 s}{t} = 0$$

The best ordering cycle: $t = \sqrt{\frac{2C_2(C_1+C_3)}{C_1 C_3 R}}$

Optimal order quantity: $s = \sqrt{\frac{2C_2 C_3 R}{C_1(C_1+C_3)}}$

110.3 Analysis of Results

Conclusion from the model given above, the best ordering cycle that allows out of stock order is longer than the previous model which doesn't allow out of stock. Under the premise of control out of stock losses, we can extend the order cycle appropriately, which can reduce ordering costs and storage costs as well as inventory risk.

The type I of material's characterized is importance and the response time needs to wait lasts long. Being out of stock order, the loss is hard to estimate and measure economic indicators. Considering the characteristics of the dangerous goods supplies, part of the material has poor physical and chemical stability which causes the risk coefficient. And it needs higher management fees. So we should appropriate to reduce the residence time of such materials in the warehouse (Xun et al. 2011).

We can extend the order cycle and reduce the number of ordering methods. Especially for the low safety factor supplies, this can directly reduce the number of storage warehouse, which can improve the efficiency of materials management and warehouse security level.

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Chapter 111
Optimization of Library Distribution Network of Singapore

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Abstract This paper describes a new designed materials distribution network of public libraries under National Library Board of Singapore. The objective is to optimize the library distribution network in order to reduce the operational cost without decreasing the customer service level in terms of total lead time. The goal is achieved by replacing the centralized sorting process with distributed pre-sorting processes at individual libraries, dividing the libraries into regions, searching for the shortest vehicle routes for each region and etc. The initial analytical results show great potential in cost saving as well as improving the efficiency of the current material distribution process of NLB.

Keywords Logistics · Library distribution network · Vehicle routing

111.1 Introduction

Singapore National Library Board (NLB) is a non-profit government organization to provide educational materials and services to its patrons. There are total of three tiers of libraries defined by National Library Board (NLB) so as to better serve its patrons as well as to engage all the libraries in a well-designed management system. The three-tier public library includes national, regional and public libraries. There are total of 24 libraries in Singapore including 1 National Library, 3 Regional Libraries and 20 Public Libraries.

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Besides operating the network of libraries, NLB also operates a Library Supply Centre (LSC) and a Network Operations Centre (NOC). Both LSC and NOC provide important support services to the libraries. LSC is a one-stop center for procuring and processing library materials while NOC provides IT support services for library operations (National Library Board 2009).

To serve the patrons with its best potential, NLB initials a unique service which is to allow nationwide materials return. This means the patrons could return the materials to any public library instead of the one that they borrowed from. However, this unique service requires much complex logistics activities. One of the most outstanding factors is the dramatic logistics cost increment in providing this service. As all of the related complex activities require a great deal of manpower and machinery, NLB has outsourced these activities to a third party logistics provider.

The aim of this paper is to optimize the library distribution network and improve the current library distribution process, in order to enhance the efficiency of the materials distribution network of public libraries of Singapore. The specific technical objectives are to:

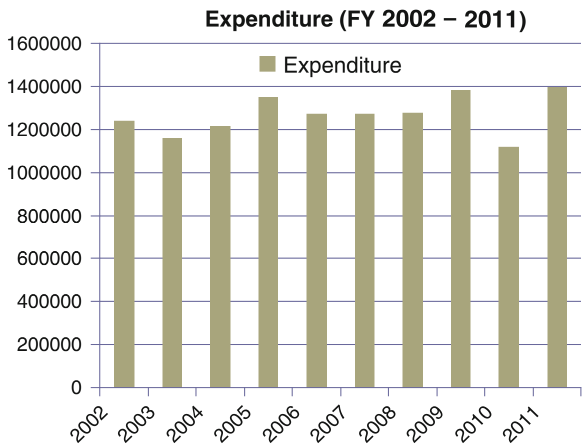
- Optimize the library distribution network in order to reduce distribution cost;
- Ensure total lead time of new network is better-off than that of the current process.

The rest of this paper will firstly describe the current library distribution network and a proposed new design of the distribution network. Then, a two- phase heuristic method is used to solve the problem and the results of shortest routes for each region will be demonstrated and discussed. Finally a conclusion summarizes this paper.

111.2 Current and a Proposed Library Materials Distribution Network

In Singapore, for the convenience of patrons, all libraries allow patrons to return books to any public libraries of NLB, no matter where the books are borrowed from. Each library has built-in "book drop" chutes which made it easier for users to return books. Behind a book drop chute, an operations room exists where books are sorted. As the book slides onto the book drop, it is recognized by a radio frequency reader that updates the user's account by canceling the loan. The books are then sorted by staffs and put away books belonging to other branches. For the books to be shelved locally, a computer displays the shelf code encoded in the RFID chip in order to simplify the sorting process. For books belonging to other branches, current library distribution network requires them to be collected back to a sorting center and consolidated with new materials at Library Supply Center (Foo et al. 2010).

Fig. 111.1 Annual total distribution cost from year 2002 to 2011



In the centralized sorting center, the returned materials and new materials are sorted and consolidated together according to 25 libraries and five category groups using sorting machines on daily basis between 8 A.M. to 12 noon. Once sorted, all materials are transported to the owning branch libraries within 24 h in order to balance the supplies in the libraries. For returned materials, this iterative process is known as “Return to Owning Branch” (RTOB).

Based on data taken from NLB yearly balance sheets, the annual total distribution costs of NLB from year 2002 to 2011 keep increasing. Figure 111.1 below shows the annual total distribution costs from year 2002 to 2011. The latest distribution cost of year 2011 was around 1.4 million Singapore dollars. Using the ratio of 75 % for sorting and 25 % for transport, future costs could reach S$2 million breaking down to S$1.5 million for sorting and S$0.5 million for transportation. Such a prediction with dramatically increased costs highly exceeds NLB’s budget.

By taking a closer look, sorting cost includes the use of high-speed sorting machines to sort the new and RTOB materials at the sorting center on daily basis, while distribution cost includes daily collection of the RTOB materials at 24 public libraries and new materials at LSC, and sending them to the sorting center. Once sorted, all materials are sent back to the designated branches within 24 h turnaround time. Currently, NLB has outsourced the sorting, transportation and other related distribution activities to a third party logistics (3PL) provider. The 3PL does daily collections from LSC and all libraries for all materials including both new materials and RTOB materials.

Therefore, it has been proposed by Chan et al. (2012) a pre-sorting process at every library’s backroom office and Library Suppliers Center (LSC). Figure 111.2 shows the concept of a new library distribution network design by replacing the sorting center with pre-sorting process at individual libraries and LSC. Such pre-sorting processes could be outsourced to a transportation company to do the sorting by bins and transport all materials to all libraries without going through the sorting center.

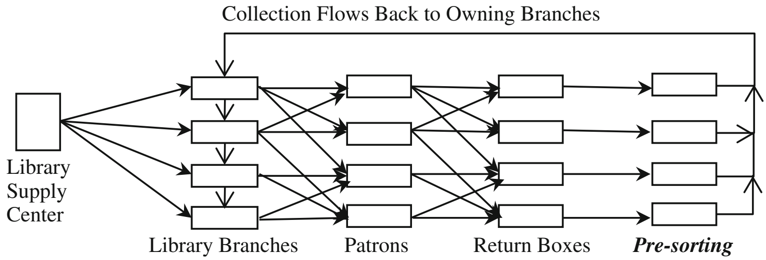


Fig. 111.2 New library distribution network with pre-sorting to replace sorting center

The library materials distribution problem is very similar to the Vehicle Routing Problem with Time Windows (VRPTW) (Solomon 1987). The VRPTW involves routing a fleet of vehicles, with limited capacities and travel times, from a central depot to a set of geographically dispersed customers with known demands within specified time windows. The time windows are two-sided, meaning that a customer must be serviced at or after its earliest time and before its latest time. If a vehicle reaches a customer before the earliest time it results in idle or waiting time. A vehicle that reaches a customer after the latest time is tardy. A service time is also associated with servicing each customer. The route cost of a vehicle is the total of the traveling time (proportional to the distance), waiting time and service time taken to visit a set of customers.

The vehicle routing problem (VRP), without time windows, is NP-complete (Christofides et al. 1989; Lenstra and Rinnooy 1981). Solomon (1987) and Savelsbergh (1985) indicate that the time constrained problem is fundamentally more difficult than a simple VRP even for a fixed fleet of vehicles. Savelsbergh (1985) has shown that finding a feasible solution for a VRPTW using a fixed fleet size is NP-complete. Due to the intrinsic difficulty of the problem, search methods based upon heuristics are most promising for solving practical size problems (Baker and Schaffer 1986; Desrochers et al. 1988; Koskosidis et al. 1992; Savelsbergh 1985, 1987; Solomon et al. 1988; Solomon 1987; Thangiah et al. 1994). Heuristic methods often produce optimum or near optimum solutions for large problems in a reasonable amount of computer time. Therefore the development of heuristic algorithms that can obtain near optimal feasible solutions for large VRPTW is of primary interest in academic world.

111.3 Two Phases Heuristics and the Results

In order to solve the library materials distribution problem, this paper is to propose a two-phases heuristics. Phase I is to segregate the whole distribution network into a number of sub-networks, or regions, with a regional library as the center for each sub-network. The rationale behind is that patrons normally return books to libraries nearby the regional libraries within the same sub-network, if not to the owing libraries. Therefore, the quantities need to be transported in between libraries within the same region are much more than that to other library regions. Formation of regions is based mainly on the distances between libraries and the number of Roller Cages (RC) needed for each library within a region.

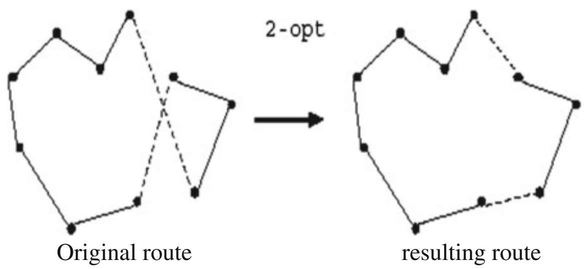
In phase II, after creating the regional groupings for the libraries, it needs to search the shortest route of a truck for each region. The vehicle routing for each region could be modeled as a single vehicle routing problem (VRP) with both pickup and delivery, and only materials sent across regions need to be consolidated at LSC. Many shortest route (time) techniques could be used to find the least amount of time it takes to travel through a region from LSC to all the libraries in a region and ends back at LSC. In this paper, two-opt heuristics is used to solve the VRP problem for each region due to relatively small number of libraries in each region.

Using two-opt heuristics, all possible pair wise exchanges of libraries within an individual vehicle route are examined to see if an overall improvement in the objective function, that is, a shorter route time, can be achieved by simply changing the order in which the libraries are visited. A typical two-opt exchange is illustrated in Fig. 111.3 (Dorigo and Stützle 2001). Two-opt exchanges are continuously performed until no more improvements can be made.

Figure 111.4 below demonstrates a result with four regions of an optimized library distribution network. Total four trucks are needed and each truck will travel through one region starting from LSC. Each truck will conduct deliveries and pickups at libraries of its region and only those materials for across regions need to be shipped back to LSC for consolidation at the end of the day. Next morning at LSC, all the RTOB materials will be sorted together with new materials before they are transported to their respective regions.

Using Region A as an example, Truck 1 will milk run through all the libraries in Region A and pick up at each library the materials, which are classified under two categories: (1) those belong to libraries within the same region and (2) those belong to libraries of other regions. Materials that belong to libraries within the same region will be sorted according to their own allocated Roller Cages inside the truck and then be delivered to its belonging libraries within Region A. While materials belonging to other regions will be shipped back to LSC, where the materials will be sorted and consolidated with new materials and waiting for next day deliveries. The shortest routes for each region are listed as below:

Fig. 111.3 Two-opt heuristics



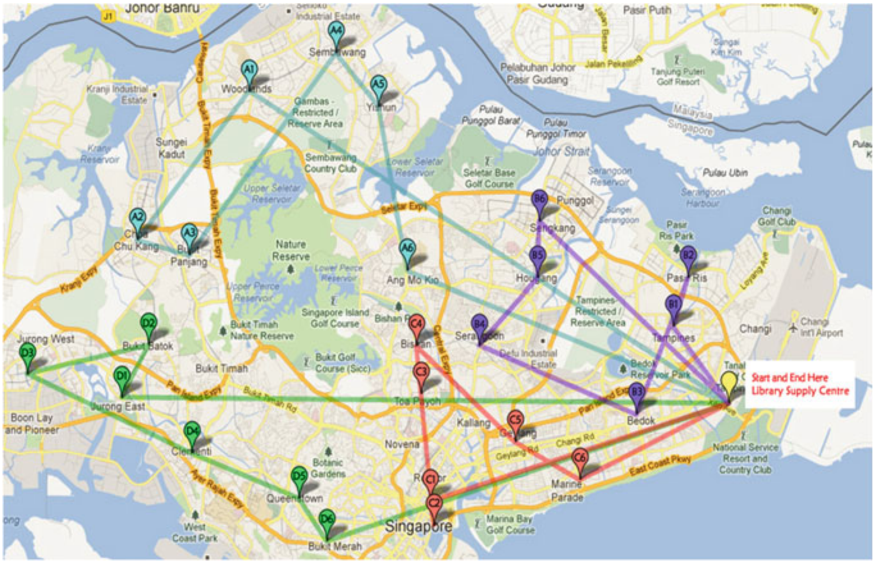


Fig. 111.4 Regional divisions of the optimized library distribution network

Region A. The route starts from LSC and the shortest route for this region is: LSC–A1(WRL)–A2(CCKPL)–A3(BPPL)–A4(SBPL)–A5(YIPL) –A6(AMKPL)–LSC.

Region B. The shortest route will be: LSC–B1(TRL)–B2(PRPL)–B3(BEPL)–B4(SRPL)–B5(CSPL)–B6(SKPL)–LSC.

Region C. The shortest route for this region is: LSC–C1(CTPL)–C2(EPPL)–C3(TPPL)–C4(BIPL)–C5(GEPL)–C6(MPPL)–LSC.

Region D. The shortest route for this region is: LSC–D1(JRL)–D2(BBPL)–D3(JWPL)–D4(CMPL)–D5(QUPL)–D6(BMPL)–LSC.

In the beginning, all trucks need to go to LSC at 12 noon to collect the new materials, reworked materials, and across regions materials, which have been sorted in the morning for respective regions. For each route, the truck will both deliver and collect materials at each library. All trucks will complete their routes and come back to LSC before it is closed at 5 p.m.

Table 111.1 shows four lists of libraries routes by regions and truck schedules for each route. Based on the truck schedules, which includes both travel time and loading unloading time, the total delivery time for each region could be calculated as below:

- Transportation time
  - Region A: 4 h 35 min
  - Region B: 4 h 25 min

Table 111.1 List of libraries routes by regions and truck schedule

Truck	Destination		Time in	Time out
Region A				
24 footer	LSC		12:00 P.M.	12:25 P.M.
	A1	WRL	12:50 P.M.	1:05 P.M.
	A2	CCKPL	1:20 P.M.	1:50 P.M.
	A3	BPPL	2:00 P.M.	2:15 P.M.
	A4	SBPL	2:35 P.M.	2:50 P.M.
	A5	YIPL	3:00 P.M.	3:20 P.M.
	A6	AMKPL	3:35 P.M.	3:50 P.M.
	LSC		4:10 P.M.	4:35 P.M.
Region B				
24 footer	LSC		12:00 P.M.	12:25 P.M.
	B1	TRL	12:35 P.M.	12:55 P.M.
	B2	PRPL	1:05 P.M.	1:35 P.M.
	B3	BEPL	1:50 P.M.	2:15 P.M.
	B4	SRPL	2:30 P.M.	2:45 P.M.
	B5	CSPL	2:55 P.M.	3:15 P.M.
	B6	SKPL	3:25 P.M.	3:45 P.M.
	LSC		4:00 P.M.	4:25 P.M.
Region C				
24 footer	LSC		12:00 P.M.	12:25 P.M.
	C1	CTPL	12:40 P.M.	1:05 P.M.
	C2	EPPL	1:10 P.M.	1:30 P.M.
	C3	TPPL	1:45 P.M.	2:15 P.M.
	C4	BIPL	2:25 P.M.	2:50 P.M.
	C5	GEPL	3:05 P.M.	3:25 P.M.
	C6	MPPL	3:35 P.M.	3:55 P.M.
	LSC		4:10 P.M.	4:35 P.M.
Region D				
24 footer	LSC		12:00 P.M.	12:25 P.M.
	D1	JRL	12:55 P.M.	1:25 P.M.
	D2	BBPL	1:35 P.M.	1:55 P.M.
	D3	JWPL	2:10 P.M.	2:40 P.M.
	D4	CMPL	2:55 P.M.	3:15 P.M.
	D5	QUPL	3:25 P.M.	3:40 P.M.
	D6	BMPL	3:50 P.M.	4:05 P.M.
	LSC		4:30 P.M.	4:55 P.M.

  - Region C: 4 h 35 min
  - Region D: 4 h 55 min

- Total lead time: 24 h

Other factors need to be examined are truck capacity and fluctuations of materials quantities in order to ensure the truck assigned to a region has sufficient capacity to carry all the roller cages on its route. The data regarding the number of

Table 111.2 Monte Carlo simulation of loading volume for Truck 1

Branch	Loading	Unloading	Rand No.	Holding RCs
A1	4	0	0.060462434	4
A2	4	3	0.897347067	5
A3	3	3	0.600747513	5
A4	3	1	0.579881272	7
A5	6	0	0.103310049	13
A6	3	0	0.099925178	16

roller cages for RTOB materials at all libraries was regularly collected by NLB. In order to understand the dynamics of loading and unloading of roller cages at each libraries along a truck route, Monte Carlo simulation is used to simulate the fluctuations of numbers of roller cages on the truck throughout the route. With the data generated from the Monte Carlo simulation, it is able to examine the sufficiency of truck capacities from statistics view.

Monte Carlo simulations are conducted to verify the hypothesis that for each route, at any time, the total number of Roller Cages will not exceed the maximum truck capacity. Table 111.2 shows an example of one instance of Monte Carlo simulation for Truck 1. Starting from LSC with beginning number of Roller Cages, the Truck 1 will do loading and unloading at each library on its route. The Loading column gives the number of loading roller cages at each library, and the Unloading column is the number of unloading roller cages at each library. Holding column is a result from Beginning No. of RC minus the Unloading, thus holding column displays the numbers of Roller Cages on the truck throughout the route. The Holding RCs from previous library plus Loading number of current library and minus Unloading number of current library is the Holding RCs of the truck after visiting current library. All numbers are generated from Monte Carlo Simulations based on randomness.

From the results of Monte Carlo simulation, it is observed that with loading and unloading of materials on a route throughout the region A, the maximum number of RCs on Truck 1 is 16, which is well within the capacity of the truck. Hence, the truck capacity is sufficient for a regular route. With many replications of Monte Carlo simulation, the maximum number of RCs on Truck 1 is always less than 24. It is confident to conclude that the capacity of Truck 1 is sufficient for Region A. Similarly, the Monte Carlo simulations are conducted for Truck 2, 3 and 4, the results supported that the trucks capacities are sufficient for all regions.

Finally, the total cost of the optimized distribution network is estimated by considering the cost of pre-sorting manpower, Trucks and Drivers, Roller Cages, Trolleys and etc. The total annual cost is estimated as S$817 thousands. There could be S$580 thousands of cost savings if compared with S$1.4 mils of current distribution network, which is equivalent to 41.6 % of cost savings.

111.4 Conclusion

This paper studied the current materials distribution network of Singapore National Library Board, and discussed an optimized distribution network to replace the centralized sorting center with distributed pre-sorting processes at individual libraries. The efficiency and costs of the optimized distribution network are compared with the existing network. Firstly, with the sorting center being removed from the optimized distribution network, it brings the savings on the labors costs, rental for the machines and etc. Secondly, total number of trucks is reduced from 5 to 4 trucks due to the milk runs of each region and only cross regions materials being sent to LSC. Thirdly, the total time taken for an average route is now reduced to less than 5 h, within which all trucks will arrive at LSC at 12 noon to collect new materials, rework materials and cross region materials and then deliver them to respective regions and return back to LSC before 5 p.m., the end of a working day.

By and large, the optimized library distribution network performs much cost effectively than the existing one. The implementation of the proposed distribution network is in process and will be reported in future publications.

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Chapter 112
Optimizing Logistics System of ZQ Ceramic

Hai-song Lin

Abstract Modern logistics is widely regarded as the "Third Profit Wellhead" by reducing the consumption of materials and improving productivity. Effective logistics distribution system is the base of enterprise developing quickly because the company is surviving and developing with intense competition which depends on Quick Response, product quality, standard of service, and serving cost to meet the need of market. In order to improve the customer satisfaction and to reduce operation cost of ZQ ceramic company, which was analyzed each link and its character systematically and resolved the problems in network design for logistics distribution system. With using integer programming method, it designed network plan to aiming at collaborative logistics operation efficiently and effectively.

Keywords Logistics · CRM · SCM · Customer satisfaction

112.1 Introduction

Distribution is a key link of logistics management in ZQ ceramic company. There are three key influencing factors, such as total logistics cost, operation capability, and customer satisfaction, which are unattached each other (Lyons 1995).

(1) Operation capability. Distribution system resolves the items which include: product quality, reducing cost, damage avoiding, quick feedback, good standard of service, and so on.
(2) Total logistics cost. With researching the decision to distribution system, it is necessary to focus on total cost and relevance of all operation synthetically.

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(3) Customer satisfaction. Good service quality can improve customer satisfaction. Service quality evaluating of distribution system is showing the matching degree to logistics delivery model.

112.2 Business Process in ZQ

ZQ ceramic is a company with distributing the disinfection ceramic tableware mainly which is based in Guangzhou city. The manufacturer of ZQ ceramic is in Chaozhou city in Guangdong province. There are more than 100 customers which are the disposable packaging of tableware sterilization centers in the Pearl River Delta. As shown in Fig. 112.1, ZQ ceramic distribution center warehouse is about 4000 m^2, about 6000 location, which are over 50 kinds of ceramic tableware which including the number of around 65 % for the same variety and the remaining 30 % more with each disinfection center is mainly mark, which includes several area: inventory area that containing three-dimensional shelves which are used for the storage of goods, cache area that is used for the goods for the temporary storage, the bad goods storage area that is used to store the damaged and goods of exceed the limited time area.

Ceramic tableware which from manufacturer were carried to Guangzhou distribution center warehouse, with adding, storage management, picking up and outbound links and so on, which finally is meeting to customers' requirements, with the help of a series of service of the formation of the link distribution services.

With analyzing the business process in practice, there are some problems existing as follows:

(1) It has run out of stock in picking–up usually. Because of the incorrect forecast and the volatility of customers' order, there is no stock in the face of picking-up.

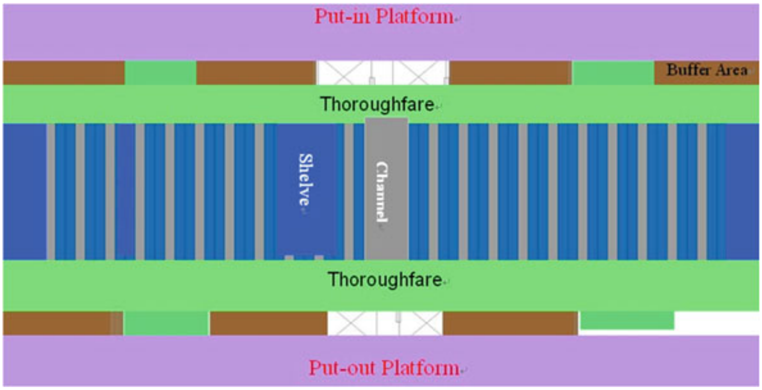


Fig. 112.1 Pane layout of ZQ ceramic distribution center

Therefore, it needs wasting some time to elevate off the stock from the high level shelves.

(2) There is no awareness of all members' cost. All work on the process of producing and circulation, the interaction among all members in supply-chain and among departments and links in enterprise members is the result for forming the cost. However, it is often that each member lies eyes on their own goodness, overlooking the other members cost in traditional supplying and purchasing relationship.

(3) There is more time to break up to part of the stock from the high level shelves. The stock which was removed after the board elevated from the high level shelves was broken up to part of the stock that will usually return to elevated up to the high level shelves.

(4) Quick response model is not established. The personal and diversified requirements of quality and variety of customer need quick response. But the customer needs weren't meet in time because the distance between some customers and Guangzhou distributing center is far which leads the customer to claim and the customer satisfaction is to turn down.

(5) There are no reviewing standard and motivation mechanism which to check user service level and cooperation partner and poor effective market system and coordination mechanism. The idealism of selfish makes motivation mechanism which does focus on owner target, only evaluating owner performance and purchasing owner benefit, which makes SCM abnormal.

Above all, it is necessary to respond to customers' need effectively and efficiently. With System in SCM based on CRM. Therefore, business enterprise to keep the core competitiveness of the key.

Supply-chain management within CRM which use CRM software system collects and analyzes the information about all members of supply-chain. Just like Fig. 112.2.

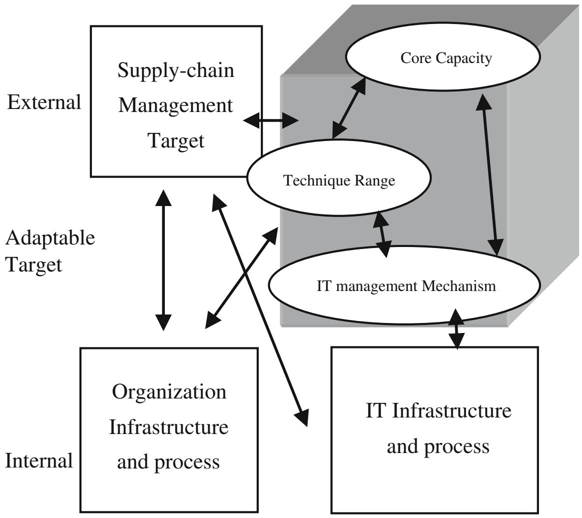
Supply-chain management within CRM means that designing logistics system of ZQ Ceramic in SCM based on CRM is to be responded by strong producing and selling, which make information communication more and more convenient and rapidly. More important, customer satisfaction will be improved.

112.3 Optimizing Logistics System in ZQ Ceramic Company

112.3.1 The Business Process Analysis for Logistics System of ZQ Ceramic Company

In order to realize the many kinds of small batch and frequency customers' requirements, to reduce the rate and out of stock of reducing distribution mistakes

Fig. 112.2 SCM information target model



and improve labor efficiency and to make distribution center work simplification. To eliminate enterprise logistics system implementation of delay, so as to improve competitiveness, improve the service level of logistics. The ultimate objective is to achieve enterprise operation cost and raise the level of customer service through the logistics is identifying the full range of customer with most valuable by the analysis result, that is to say, what look for the important and appropriate customer that should be cared with CRM, what improve customer satisfaction and steadying customer loyalty.

Cooperation with the full range of customer with most valuable and R&D the product (service) to meet the diversified and personal needs of customer, what's more, supplying the product (service) conveniently and rapidly.

Supply-chain management within CRM can form value chain network. The following ways are integrated to improve the whole core competence of Supply-chain management within CRM. Just like Fig. 112.3.

112.3.2 Significance

Supply-chain management within CRM in ZQ Ceramic makes steady customer relationship, and which guarantees synergy of supply-chain. The upwards enterprises which look downwards one as customers will try their best to optimize operation process to meet customers' needs and to satisfied customers. The downwards one which is supplied with good product or service are willing to enhancing the purchasing and supplying relationship with understanding and supporting. With long-term customer relationship, the upwards have the impetus to optimize product or service and focus on CRM.

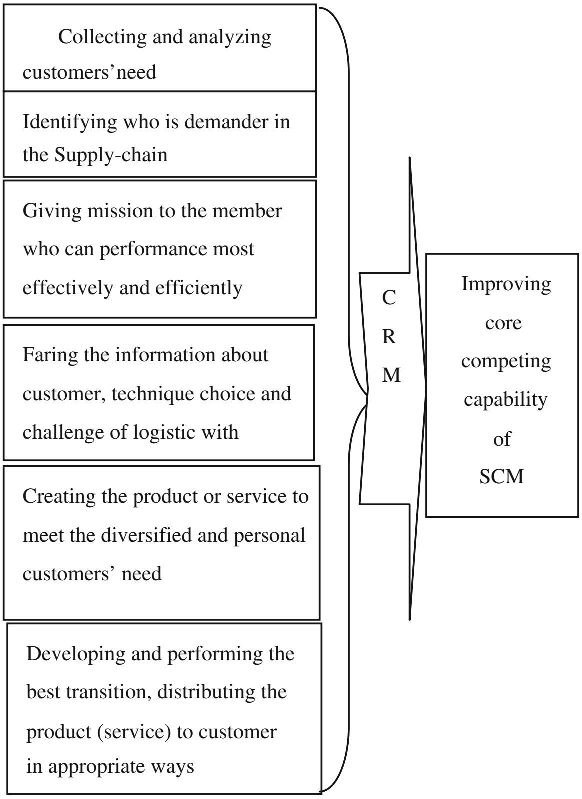


Fig. 112.3 SCM within CRM model

(1) Long-term steady customers' relationship is good to reduce the cost of looking for customers. It is investigated that the cost of maintaining an old customer is 1/5 to the one of developing a new customer.
(2) The experience to process operation can make operation process in turn and optimize each joint of all members that supply good product and convenient service. That is to say, process optimizing means reduce the cost of SCM and good product and convenient service supplying can achieve more customer. In all, it is to increase income and decrease expenditure.
(3) The original of core thinking with full range of customer relationship management is that meeting diversified and personal needs of final user. The thinking of full range of customer relationship management means that supply-chain management within CRM in ZQ Ceramic is a value creating system with all members. Customers are not the receiver from product or service value, but are the partners that can participate in supply-chain management within CRM in ZQ Ceramic to create value. The process of value creating in supply-chain management within CRM will be finished IT Platform, at which the process of product or service R&D is open up to customer and by which information of customers' need and hope or change communicate and feedback.

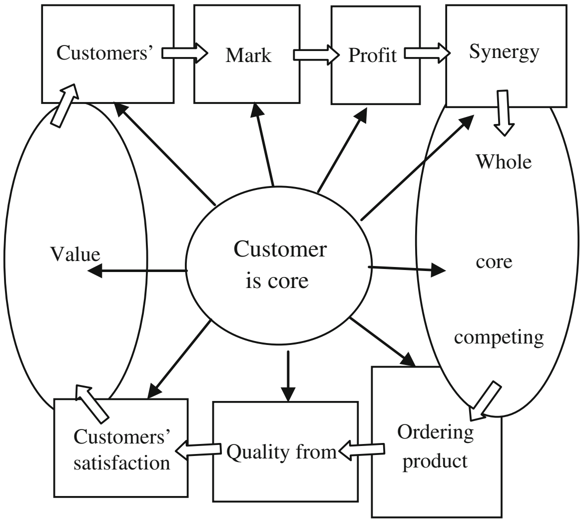


Fig. 112.4 System of value creating in supply-chain management within CRM

The system of value creating in supply-chain management within CRM in ZQ Ceramic means customer satisfaction maximization and whole core competing capacity of SCM, which includes interaction to circulate. In whole, it is a system of value creating with the idea that customer is core, just as Fig. 112.4.

112.4 Conclusion

With the goal is to improve enterprise logistics management efficiently, it puts forward the concrete and feasible solution for the enterprises to improve customer satisfaction and to save the operating cost. With the thinking of the full of range of customer relationship in Supply-chain management within CRM in ZQ Ceramic company is achieving true information faring, studying and analyzing owner customer of member and mutual customer and improving customer satisfaction and steadying customer loyalty, maximizing customer value within CRM.

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Chapter 113
Pricing Strategy Research of Green Supply Chain Based on Products Substitution

Yi Zheng, Fang Hu and Yu-jiao Xu

Abstract Green supply chain, as an emerging enterprise strategic management model, governments, enterprises and academic circles have attached more and more great importance to it, which is an essential way of realizing sustainable development of enterprises. Price strategy is helpful to improve the operation quality and benefit of the supply chain, and realize the coordination of green supply chain. On the current market, green products and general products coexist, the same as the basic functions of those two categories, but the green products can give consumers additional social responsibility. This article puts forward a social responsibility payment factor to represent the price interval that consumers willing to pay more for the green products because they have a preference for it. Get the optimal price of green products by discussion, and make the profits of green supply chain to maximize.

Keywords Green supply chain · Products · Pricing substitution

113.1 Introduction

Twentieth Century has witnessed the rapid development of human society, but this development has also posed several threats, such as resource exhaustion, environmental pollution and ecological imbalance, etc. Manufacturing—as a pillar industry of the national economy—has been creating abundant material wealth for the whole society; however, it has wasted large amounts of resources at the same

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time. Therefore, in order to minimize damages to the environment and make the manufacturing industry use resources efficiently, scholars both at home and abroad have dedicated to the research and application of green manufacturing (Melnyk and Smith 1996; Meng et al. 2009). Since Michigan State University has put forward the concept of green supply chain in 1996, different scholars have observed and researched green supply chain management from various angles. What they have researched mainly includes three aspects: the definition, elements and structures of green supply chain (Liu et al. 1998; Nagel 2000; Zsidisin and Siferd 2001); the operation of green supply chain (Dan and Liu 2000; Nagurney and Toyasaki 2003; Noci 1997; Sarkis 2003); and the relationship between green supply chain management and enterprise performance (Seuring 2001). In the fields of cooperative relationship, pricing and coordination research between members in the green supply chain, Luo, Li and Carter have studied the factors that would have influences on the cooperation between members in the green supply chain from the empirical perspective (Carter et al. 2000; Li et al. 2001; Luo and Zhao 2005; Zhu 2004). Wang (2003) thought of the pricing of green products from two cases—the action and inaction of ordinary product provider. Mu and Li (2005) established monopoly competitive model between two businesses from the angle of product differentiation, and proved that when the cost of environmental quality increased, and consumers have different preferences on the environmental impacts of products, manufacturers that produce clean products can gain more profits than those produce pollution products-adopting differentiation strategy to improve competitiveness; Zhang and Zhang (2005) established a cost and profit measuring model of green product in manufacturing industry, and put forward a goal programming model based on the opportunity cost, which can maximize the social benefits and economic benefits of green products, and the results can help manufacturing enterprises have an objective evaluation on whether bring green products into production or not. Zhang and Zhang (2005) researched the pricing and coordination mechanism of products and raw material in the green supply chain, all the studies are on the condition that green products and common products coexist and consumers have different preferences for these two different type of products, from this a conclusion can be drawn that the collaboration between manufacturers and suppliers not only can make consumers choose green products as the object of consumption, and both sides realize the Pareto improvement of profits, ensure the stable operation of the supply chain.

Under the present conditions, consumers have different preferences for green products and general products on the market. Therefore, how to let customers choose green products as the object of consumption from the utility maximization angle through reasonable pricing is essential for the effective operation of the green supply chain. This article considered from the perspective of social responsibility and introduced the social responsibility factor "θ", shows that consumers have the desire to pay more a certain price range for green products. Set down the optimal price of green products and maximize the whole profits of green supply chain. This article provides useful references for the pricing decision-making of green products on the market where these two categories of products coexist.

113.2 Problem Model

Considering a class of stable product marketing, products are in the mature period, its supply chain consists of a manufacturer, a retailer and a consumer groups that green consumers have homogeneous demands. The market price of its general product is P_N assuming that the general production cost is negligible, the green production cost is C_g, and the market price of green products is

$$P_g = (1+\theta)P_N. \tag{113.1}$$

$$\theta = \frac{p_g}{p_N} - 1 = \frac{p_g - p_N}{p_N}$$

In this formula is the social responsibility payment factor, which refers to the money those consumers willing to pay more for green product. Assuming there is a consumer group that capacity of their markets is 1 on the current market. θ represents the social responsibility payment factor of green product that consumers want to buy. And assuming that the social responsibility payment.

Factor θ is uniform distribution between θ_1 and θ_2. When $P_N + \theta \bullet P_N > P_g$, that is to say, when the price of green product is lower than the money that consumers willing to pay, consumers are willing to buy green products, and buy general products on the contrary. That means, whether consumers buy green products is determined by θ. We define $1-\theta$ as the degree consumers can accept, the social responsibility payment factor θ smaller, consumers' acceptability bigger, and consumers tend to buy green products, otherwise they choose to buy general products. Therefore, if you want consumers to buy green products, then the degree consumers can accept should meet:

$$1 - \theta \geq 0. \tag{113.2}$$

For enterprises, only when the social responsibility payment factor $\theta \geq 0$, enterprises can obtain the chance to gain more profits than ordinary products, and use it to encourage enterprises to further the development of green products and make enterprises the research and development leader in this product. From the above we can know $\theta \in [0, 1]$, so, the critical value of consumers' expectation of social responsibility payment factor $\theta*$ should meet:

$$P_N + \theta^* \bullet P_N = P_g \, (\theta^* \in [\theta_1, \theta_2]). \tag{113.3}$$

And we can gain:

$$\theta^* = \frac{p_g}{p_N} - 1 = \frac{p_g - p_N}{p_N}. \tag{113.4}$$

Then the green products' needs of market are:

$$Q = 1 \cdot \int_{\theta}^{\theta_2} \frac{1}{\theta_2 - \theta_1} d_\theta = \frac{\theta}{\theta_2 - \theta_1}\Bigg|_{\theta}^{\theta_2} = \frac{\theta_2 - \theta}{\theta_2 - \theta_1} = \frac{\frac{p_{g2} - p_N}{p_N} - \frac{p_g - p_N}{p_N}}{\frac{p_{g2} - p_N}{p_N} - \frac{p_{g1} - p_N}{p_N}} = \frac{p_{g_2} - p_g}{p_{g_2} - p_{g_1}}. \tag{113.5}$$

Then the expected profits for green supply chain are:

$$T_g = \int_0^Q (p_g - c_g) d_Q = (p_g - c_g) Q|_0^Q \tag{113.6}$$

$$T_g = (p_g - c_g) \frac{p_{g_2} - p_g}{p_{g_2} - p_{g_1}}. \tag{113.7}$$

Let $\frac{\partial T_g}{\partial P_g} = 0$,
we can gain:

$$p_g^* = \frac{p_{g_2} + c_g}{2} \tag{113.8}$$

$$\therefore T_g = \left(\frac{p_{g_2} - c_g}{2}\right)^2 \times \frac{1}{p_{g_2} - p_{g_1}} \tag{113.9}$$

$$p_{g_2} = (1 + \theta_2) p_N \tag{113.10}$$

$$p_{g_1} = (1 + \theta_1) p_N \,(\text{we already know } \theta_1, \theta_2) \tag{113.11}$$

$$T_g = \left(\frac{(1 + \theta_2) p_N - c_g}{2}\right)^2 \times \frac{1}{(\theta_2 - \theta_1) p_N}. \tag{113.12}$$

We substitute (113.8) into (113.6) and know:

$$p_g^* = \frac{(1 + \theta_2) p_N + c_g}{2}. \tag{113.13}$$

In order to ensure the optimal price we ask for p_g^* is in the section $\left(p_{g_1}, p_{g_2}\right)$, hereby verify it:

We can gain from (113.1):

$$\begin{cases} P_{g_2} - P_{g^*} = (1 + \theta_2) P_N - (1 + \theta^*) P_N = (\theta_2 - \theta^*) P_N \geq 0 \\ P_{g^*} - P_{g_1} = (1 + \theta^*) P_N - (1 + \theta_1) P_N = (\theta^* - \theta_1) P_N \geq 0 \end{cases}.$$

Table 113.1 A green pork market relevant data

Variable	θ_1	θ_2	P_N	C_g	C_N
Values	0.20	0.80	18 .00	24 .00	14.00

So, p_g^* is in the extent of $\left(p_{g_1}, p_{g_2}\right)$, then p_g^* is the optimal price. So we can know the optimal price of a green product is $p_g^* = \frac{(1+\theta_2)p_N + c_g}{2}$, at this point, the profits of this whole supply chain is the biggest.

113.3 Example Analysis

Hypothesis that, after the research to one market, we found that customers have potential requirements to organic meat. Therefore, a green supply chain alliance supply for green pork, the related data are shown below:

113.3.1 References

Then we can get the optimal price P_{g^*} of 28.20,at this time the price change factor $\theta^* \approx 0.567$, the degree consumers can accept is about 0.433, the demand $Q = 0.3889$. This suggests that green pork pricing in a rational scope and consumer can accept. If the market has the total demand for thirty thousand kilograms of pork, so the total demand for green pork is about 11667 kg, and its biggest profits at about $49000, and the total demand for not green pork is about 18333 kg, the total profit about 73300 yuan. Compared the total demand and total profit of pork with the green pork respectively, it is concluded that the profit of per green pork was higher than the not green pork. Thus, as long as the enterprise can pricing the green product reasonably, it will stimulate the consumption, then obtain more profits for the enterprises, and also protect the environment, make the whole supply chain for the biggest profit (Table 113.1).

With the progress of the times, the public awareness of environment protecting will also growing, and green products will get the public's favorite more and more. We believe that the development of green products will be a new business opportunity and challenge.

113.4 Conclusion

This study shows that in the situation of the collaboration of suppliers, the manufacturers and sellers, concentrated pricing can make green supply chain system profit maximization. The basic function of green products and ordinary products is the same; differences exist in social responsibility, so consumers are willing to pay extra for this part of the price to buy green products. If it is priced higher than the consumer's willingness to pay, which will greatly reduce the consumers' willingness to buy, making the profit of the whole of green supply chain low and even a loss, so as to the failure of the optimal pricing strategy of green supply chain. This article mainly do researches on how price influence the alternative of green product related to common products, and in the market, green products and common product has some of the alternative, and in the market of different preferences conditions, social obligation payment factor change in a reasonable scope. When $\theta = \theta^{*}$, the price P is the best price and the entire green supply chain get the max profit. In fact, when consumers are choosing to buy green products whether to buy the green products still depends on the strength of the environmental protection consciousness and the propaganda on green products of government departments, social public opinion, and all kinds of incentive mechanism, project fund for the support for green products project. But as the present situation of economic development and the Chinese laws and regulations are not perfect, it makes the government's support to green product enterprise cannot achieve the best. This will be our next step in the direction of the study, so as to provide scientific basis for government departments, and making the best scheme to encourage enterprise of green product development, providing effective incentive and policy support to the feasible green supply chain.

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Chapter 114
Recent Heuristics and Algorithms for Solving the Vehicle Routing Problems

A. A. Abdelhalim and A. B. Eltawil

Abstract The exponential rise in the advances of computing power has opened new domains for better solutions for the different classes of the Vehicle Routing Problems (VRP). This paper sheds some light on the recent work published in this field of interest and provides a classification of different problem structures and the solution methodologies used to tackle every class. The classification is made considering the limited space and to the best of our knowledge. Some of the current applications of the vehicle routing problem are also included in this paper. Finally, a discussion on the possible future directions and conclusion is presented in the last section.

Keywords GIS · Heuristics · Nature inspired intelligence · RFID · VRP

114.1 Introduction

The fierce competition in today's global market is driving companies and different business entities to run their businesses based on the on-time delivery, quality, value and the total cost. One of the most costly and challenging tasks is the transportation and distribution systems. This is one of the reasons for the rise in the research interest to study the logistics network design and in particular, the VRP. The VRP is concerned with finding the optimal or near optimal routing sequence of a set of dispersed customers or locations to fulfill their demand. Many variants

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can be incorporated to shape the final structure of the model describing the VRP depending on each case solved. Among those variants are the capacity limitation imposed on vehicles and sometimes the route itself in terms of length or duration. There is also limitation in some cases on the time window allowed for each vehicle in visiting locations. An important application is the courier mail service depicted by the VRP with pickup and delivery.

The paper is organized as follows; in Sect. 114.2, a brief history of the VRP is presented. Section 114.3 reviews some attempts previously made in literature to classify the VRP, and Sect. 114.4 presents a classification of the most commonly addressed variants in VRP found in literature. Section 114.5 gives a brief overview on the most recent critical application in the recent few years in literature. Finally, in Sect. 114.6 a gap analysis conducted are presented in the future research directions and conclusions.

114.2 Vehicle Routing Problem History

The breakthrough in the solution methodologies for the Traveling Salesman Problem (TSP) was introduced in 1954 by Dantzig et al. (1954) describing a method for solving the TSP with emphasis on its power by solving an instance of 49 cities, which was an impressive number at that time. Few years later, in 1959, Dantzig and Ramser studied the solution approaches to solve the vehicle routing problem (Dantzig and Ramser 1959). Ever since their publication, a long chain of published work modified and/or extended their original model.

The VRP has wide variants that make it difficult to come to one consensus on which the VRP can be classified. Consequently, many attempts took place in order to classify the VRP. Many publications considered a single depot that all vehicles start and end at as found in Baker and Ayechew (2003), Godinho et al. (2008), Kang et al. (2008), Bin et al. (2009) and few others considered multi-depot vehicle routing problem; Ho et al. (2008) and Chan et al. (2001). Another variant is the so called split delivery problem that a location can be visited by two or more vehicles, and although this option is considered as a relaxation to the VRP, it is even harder to be solved than the standard VRP; as illustrated in Tavakkoli-Moghaddam et al. (2006), Ho et al. (2008), Hadjar and Soumis (2009). One of the interesting findings by Eksioglu et al. (2009) is the increasing interest in the past decade till the present time in studying the vehicle routing problem due to the advances in the computing power of the hard ware equipments as illustrated in their work in Fig. 114.1.

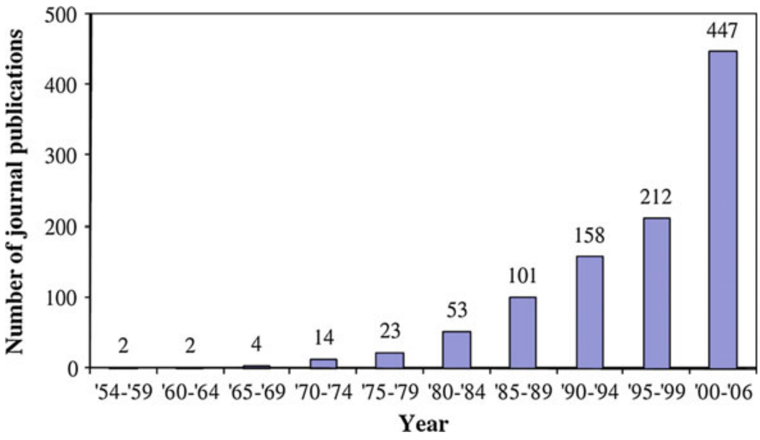

Fig. 114.1 Number of VRP articles published in refereed journals from 1954 to 2006 (Eksioglu et al. 2009)

114.3 Proposed Classifications of VRP in Literature

Barnhart and Laporte (2007) suggested four classification for the VRP:

(1) *Classical Vehicle Routing Problem*s *(VRP)*: It has given rise to different solution techniques to be thought of and utilized, either exact or heuristics, as it generalizes the TSP.
(2) *The Vehicle Routing Problem with Time Windows (VRPTW)*: In this type of problems, each stop shall be visited only within an allowable time window.
(3) *The Inventory Routing Problem (IRP)*: The IRP is an important extension of the VRP that takes into account not only the routing decisions, but the inventory decisions of the source and destination as well.
(4) *The Stochastic Vehicle Routing Problem (SVRP)*: Stochastic vehicle routing models are made to mimic the realistic situation of the uncertainty inherited in day-to-day different transactions.

Another classification by Pisinger and Ropke (2007) divided the VRP into five classifications according to the most commonly addressed variants in VRP: VRPTW, Capacitated Vehicle Routing Problem (CVRP), Multi-depot Vehicle Routing Problem (MDVRP), Site-dependent Vehicle Routing Problem (SDVRP), Open Vehicle Routing Problem (OVRP). In the CVRP there is a limited capacity on which any vehicle shall fulfill the demand of any customer starting and ending at a single depot. In some versions, not only the capacity of the vehicles is considered, however, the route capacity as well represented as route duration time or length limits. As obvious from its title, the MDVRP considers more complicated class of the VRP where the model has to consider a multi-depot instead of a single depot to construct the routes. On the other hand, the SDVRP is another extension of the VRP in which certain customers can only be served by certain vehicles.

Another classification of Baldacci et al. (2012) divided the problems into two main types, CVRP and VRPTW focusing on the recent exact algorithms to solve these two types. Nevertheless, to realize how complicated and difficult to classify the VRP into one classification that is being agreed upon by literature in the field one can refer to the taxonomy provided by Eksioglu et al. (2009).

114.4 VRP Classification

This paper presents a proposed classification into four types of the VRP variants that are commonly found in literature according to the best of our knowledge and given the limited space.

114.4.1 Capacitated Vehicle Routing Problem (CVRP)

Lin and Kwok (2006) compared between the simultaneous approach versus the sequential one to solve an integrated logistic system where decisions on the depot locations, routing of vehicles, and the assignment of routes to vehicles are considered. They showed interesting results where the simultaneous method had advantage over the sequential one in problems where routes were capacity-constrained, but not in the time dimension.

During the last decade, the nature inspired intelligence has invaded the world of the solution methodologies and created new paradigms in advanced information systems design. Whether it is Genetic Algorithm (GA), Immune System (IS), the Swarm Intelligence including Particle Swarm Optimization (PSO), or the bee and ant colonies algorithms; they all proved, through hundreds of the published work, their superiority of tackling the class of the hard problems such as the VRP. Additionally, they are being hybridized with one or more other heuristic procedure to take the solution results even to a higher quality and solve more efficiently. PSO is originally attributed to Kennedy and Eberhart (1995) and Shi and Eberhart (1998). The first intention of producing such heuristic is to simulate the social behavior, as inspired by fish schooling and birds flocking. Now the algorithm is being used in performing optimization.

A distinguish from the traditional VRP, Marinakis and Marinaki (2010b) addressed the issue of uncertainty nature by solving a probabilistic traveling salesman problem. By “probabilistic”, the authors mentioned that the number of customers to be visited each time is a random variable. They used a hybrid algorithmic approach based on Particle Swarm Optimization (PSO), Greedy Randomized Adaptive Search Procedure (GRASP), and Expanded Neighborhood Search (ENS) to solve their model. The authors compared their proposed heuristic to other heuristics and algorithms by solving the same set of problems. The results showed better performance. Tang et al. (2010) considered a different variant of the

VRP, which is the minimization of the vehicle load cost. As the vehicles vary from one customer to another, the authors believed that not considering the loading cost will lead to sub-optimal solutions. In another attempt to solve a basic VRP, Baker and Ayechew (2003) considered the genetic algorithm hybridized with neighborhood search methods. In their work, they compared the results obtained from their work with the results obtained using tabu search and simulated annealing, their developed approach was competitive in terms of solution time and quality. Ai and Kachitvichyanukul (2009b) solved the CVRP by presenting two solution approaches each with the corresponding decoding method. The first solution is an $(n + 2\ m)$-dimensional particle for n customers and m vehicles. The decoding of this representation started with transforming particles into a priority list of customers entering route and a priority matrix of vehicles to serve each customer. Their second representation was a $3\ m$-dimensional particle and its decoding started with a vehicle orientation points and the vehicle coverage radius. The authors used GLNPSO testing their proposed representations using some benchmark problems. However, other work benefited from the improvements imposed on the solution quality and efficiency as well from hybridizing the PSO with one or more algorithms. In this sense, Marikakis et al. (2010) introduced a new hybrid algorithm based on PSO to solve a large scale VRP as well as other more difficult combinatorial optimization problems. Their new hybrid method combined PSO algorithm, the Multiple Phase Neighborhood Search-Greedy Randomized Adaptive Search Procedure (MPNS-GRASP) algorithm, the Expanding Neighborhood Search (ENS) strategy and Path Relinking (PR) strategy. In another work, combining genetic algorithms and PSO with ENS, as a speeding technique, with MPNS-GRASP for producing as good as possible initial solution, led Marinakis and Marinaki (2010a) to a very fast and efficient algorithm as they claimed.

114.4.2 Multi-depot Vehicle Routing Problem (MDVRP)

Taking into account a more complicated variant of the VRP, Ho et al. (2008) focused on the vehicle routing problem with multi-depot consideration. To deal with the problem the authors developed two hybrid genetic algorithms whereas the only major difference between them is that the initial solution was generated randomly in the first algorithm. On the other hand, the Clarke and Wright saving method and the nearest neighbor heuristic were incorporated into the second algorithm for initialization procedure issues. Chan et al. (2001) studied few variants of the VRP. First, the authors formulated the complete multi-depot and multiple-vehicle routing problem deterministically. They considered this first model as a lower bound for heuristic validation purposes. Thereafter, they provided a stochastic multiple-vehicle routing and multiple facility location problems in which demands were fulfilled.

114.4.3 Vehicle Routing Problem with Pickup and Delivery (VRPPD)

In this class, Subramanian et al. (2010) presented a parallel algorithm embedded with a multi-start heuristic consisting of a variable neighborhood descent procedure, with a random neighborhood ordering, integrated in an iterated local search framework. Raising the complexity level of modeling a vehicle routing problem, Rieck and Zimmermann (2009) considered heterogeneous fleet, time windows, simultaneous pickup and delivery at customer locations and multiple uses of vehicles. The authors considered this solution methodology to tackle the problem of medium-sized less-than-truck-load (LTL) carriers operations. In another work, Lin (2008) studied a cooperative deterministic vehicle routing with pickup and delivery time windows. By minimizing fixed and traveling costs, the model determines the resource requirements and daily routing. Experimenting real and simulated data, the author showed that the cooperative approach may achieve cost savings over the independent one. On the other hand, Wassan et al. (2008) solved the VRP with Pickup and Delivery (VRPPD) using a reactive tabu search metaheuristic. The metaheuristic is designed to check feasibility of proposed moves quickly and react to repetitions to guide the search. According to their presented results, several new best solutions were found for benchmark problems. Ai and Kachitvichyanukul utilized the PSO solution approach. The authors proposed a formulation for the vehicle routing problem with simultaneous pickup and delivery (Ai and Kachitvichyanukul 2009a). They used PSO with multiple social structures based on Global Best, Local Best, and Near Neighbor Best (GLNPSO).

114.4.4 Vehicle Routing Problem with Time Windows (VRPTW)

Le Bouthillier and Crainic (2005) solved the vehicle routing problem with time windows. The authors based their methodology on the solution warehouse strategy as a parallel cooperative multi-search method. In this method several search threads cooperate by asynchronously exchanging information on the best solutions identified. As far as their test problems, the authors claimed that their procedure identified solutions that are in comparable quality of the known best methods in literature to the best of their knowledge.

Developing the VRP with backhaul as a rich pickup and delivery problem with time windows, Pisinger and Ropke (2007) proposed a general heuristic to solve this problem through an improved version of the large neighborhood search heuristic. A year later, Ropke and Pisinger (2006) solved five different variants of the problem with an Adaptive Large Neighborhood Search (ALNS). Ho and Haugland (2004) considered one of the supposed relaxations of the VRP which is the vehicle routing problem with time windows and split deliveries. The authors used tabu search without imposing any restrictions on the split delivery option. Another way of utilizing genetic algorithm, Ghoseiria and Ghannadpoura (2010) used goal programming to solve a multi-objective VRPTW in which a selection of an aspiration level is set to the objective function while deviations from this level is being minimized. The authors incorporated some other heuristics with the genetic algorithm to improve the overall performance such as the local exploitation in the evolutionary search and the concept of Pareto optimality for the multi-objective optimization. In addition, they used the Push Forward Insertion Heuristics and interchange mechanism as part of randomly initializing the initial population.

114.5 Vehicle Routing Problems' Most Critical Applications

The applications of the VRP in life, business and industry are very wide, as one can find it in the crew scheduling, bank ATM replenishments, food and retail supply, courier mail service, waste collection management, and many other applications. It was even considered by some work in the container load from/to an intermodal terminal as addressing it as vehicle routing with pickup and delivery by Imai et al. (2007). On the other hand, the rapid growth of today's world population especially in developing countries is taking the attention to the massive amount of waste generated in those areas, not only for environmental concerns, but more importantly for health concerns as well. A significant number of articles are published in the area considering the vehicle routing problem with time windows as one of the major issues in waste collection planning and management. The dilemma between not visiting a collection point, whether it is municipal waste or a medical one, too early before a certain amount of waste is gathered is considered a waste of the vehicle's operational cost including the driver's time. On the other hand, visiting a collection point after the time specified will generate too much waste that will impose hazardous effect on its surrounding area and this is also unacceptable. Hence, not only time windows consideration is a critical issue, but also knowing, dynamically, the amount of waste generated at every collection point. This information is required to generate the necessary routes accordingly.

Consequently, the advances in Geographic Information Systems (GIS) and Radio Frequency Identification (RFID) have made a great impact in such applications. Several publications made use of these tools in developing waste collection model either using RFID or GIS or both. Ustundag and Cevican (2008) developed a mathematical model for the routing problem that describes their case and solved 15 locations; benefiting from using RFID to know the location of the bin a priori. Also, it is used to be able to know the weight of the bin because the reader of the RFID has an accurate weighing system to determine the net weight of the waste bin. Nolz et al. (2011) considered a problem of routing the collection of boxes containing infectious material brought by patients to pharmacies using the

RFID. Implementing the RFID system caused significant reduction in costs and achieved high satisfaction by the pharmacist when applied on a real case containing 30 pharmacies. In another case study in Asansol Municipality, Ghose et al. (2006) developed modules in Arc-GIS software to come up with the solution of routing for a heterogeneous fleet of vehicles which collect different sizes of bins.

In an attempt to reduce the fuel consumption and atmospheric pollutant emissions, Tavares used 3D GIS for the optimization of the municipal solid waste collection routes. The 3D-GIS had significant benefit in their case due to the vast variances of inclination in the roads of Praia city where they applied their model. The authors investigated two scenarios; the first one minimizes the fuel consumption and the second one gives the shortest path. The two solutions gave two completely different routes. And the question one shall ask is that which one of the two scenarios is better. The answer to this question will largely depend on the specific case and the objectives from such model with the priority given for each objective.

Although all the presented cases have done fairly good work in addressing the VRP, however, most of them tackled a small to medium size problem. In one aspect this is not a flaw as long as the service is made and the objective of obtaining the plan is done with satisfaction from both the service provider and the client. In another aspect, considering large scale problems for a whole city or district may result in more cost savings and better service quality which was not extensively tackled in literature.

114.6 Future Research Directions and Conclusions

The vast amount of research is focusing on the theoretical background and solution methodologies for the VRP. Most published papers are focusing on the solution methodologies comparing their results either with a benchmark problem or with others' work that solved same problem variant(s). Nonetheless, some of the shortcomings were noticed in the VRP literature. The role of research now is to address and to give more attention to the applicability of the models in real cases and real applications rather than focusing only on theoretical models. Among the shortcomings found also in literature is the lack of the dynamicity of the models to deal with the demands, number of customers to be served, and some other parameters with uncertainty nature. Additionally, describing the variants considered in the proposed model was vague in many publications. Publications should describe the variants that were considered in their model structure clearly for comparison purposes. Nevertheless, It is worth mentioning that recently there is an increasing trend for using PSO in solving the VRP.

The VRPs were always considered as mathematical challenge problems. However, in recent concerns with the environmental awareness vehicle routing problems are being considered not only for reducing cost but reducing emissions as well. Additionally, the fast growth of the population and consequently the huge amount of waste generated took the attention to waste collection management. The study in this area is not as large as studying purely the VRP, though, the published papers to the best of our knowledge made a good work in terms of the service provided for the real cases solved. Nonetheless, GIS and RFID were rarely integrated in one model. This may be regarded to the fact that there is a technology and implementation challenge. Besides, systems tend to be resistant to changes. Thus, building a routing system that integrates GIS, RFID and Global Positioning System (GPS) will give higher accuracy to the generated plans. Also, utilizing the heuristics rather than just the plain modeling and simple optimization will allow more variants of the VRP to be included and hence simulate as close as possible the real case.

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Chapter 115
Research and Analysis for Transport Packaging Based on the Modern Logistics

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Abstract Based on the analysis of relationship between transportation and packing in the modern logistics system, this thesis shows the deep discussions of rationalization application at transport packaging size and transport packaging information in modern logistics system, focuses on the coordination with transport package size and container size, relationship with logistics modulus, and transport packaging information technology in modern logistics system widely used. Research and analysis for transport packaging is meaningful, which is contribute to give full play to the function of transport packaging, promote packaging with other logistics links effectively, improve the overall efficiency of modern logistics.

Keywords Logistics · Packaging · Size · Transport

115.1 Introduction

Packaging is set as the logistics origin, is the guarantee to keep supplies safe and intact in the circulation process and transport is the implementation rapid flow of the action basis in the modern logistics system.

Research and analysis for transport packaging based on the modern logistics, partly in order to further play the positive role of packaging, to minimize the material non-normal damage or injury. On the other hand, the research of rationalization, standardization, information technology about transportation packaging,

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it will contribute to achieve the effective integration of the modern logistics system, convergence, the overall optimal efficiency, improve the efficiency and effectiveness of modern logistics.

115.2 Relationship Between Transportation and Packaging

Relationship between transportation and packaging is interactive. The protection function of the packaging make the materials security in the whole process of transportation, make the storage and transport loading and unloading convenient, and accelerate the transfer and inspection. It is benefit to improve the efficiency of the transportation of materials, reduce damage degree, reduce the transportation cost, achieve cost-effectiveness ratio optimal in the end.

115.2.1 The Interaction Relations Among the Packaging and Mode of Transport, Means of Transport

The degree of packing of goods, packaging specifications and size will affect the mode of transport, as well as the choice of means of transport in the same mode. The whole process of transportation, impact, vibration loading always affects the quality and safety of the materials, such as cars, trains and other means of transport which start, transmission, steering, brake will make the speed of goods change. Due to road conditions, rail joints, engine vibration, vehicle shock resistance, surface waves, airflow intensity and other factors, it results the means of transport thrashing and rocking in a periodicity. If the stacking looses, or is not taken fixation, cargo is inclined to collision with compartment or adjacent cargo. Therefore, the degree of packing of goods, packaging specifications and dimensions should be fully consistent with the choice of means of transport (Xu 2007).

115.2.2 Trade-Off in Transportation and Package

Trade-Off means various functions of logistic are in a system as a unity of opposites. Optimization of any functional element will cause benefit loss of another one or more functional elements, and viceversa. Regarding packing and transition, in order to reduce cost of package, material will be reduced. But this will reduce the packaging strength, which will increase possibility of package damage in transportation, and finally increase cost of transportation. Due to reducing of package cost is lower than reducing of transportation cost, the total cost of logistic will be increased.

In modern logistic, social and economic benefits are pursued, trying to ensure the balance of security and cost. The demand of package for rational transition needs to balance package cost and transport modes. Generally, there are more possibility of shock and vibration in railway transport, and it needs more time and has more possibility of damage. Road transport is better, and air transport is best. But cost of railway transport is lowest, road transport is higher, and air transport is highest. Therefore, before packing goods, we have to consider both transportation safety, transport cost and transport modes and vehicles (Li 2006).

Of course, this trade-off phenomenon in relative effect exists in other process of logistic, like storage, handling and distribution. So, besides balancing package and transportation, we need to balance relation between them and other process to pursue maximum benefits of logistic system (Cai 2007).

115.3 Rationalization Application of Packaging Dimension During Transition in Modern Logistic

Standardization of packaging dimension in transition is the base of standardization for transportation conveyance and machinery. It is beneficial to improve the adaptive ability of material to various transportation conveyances, and the level of standardization for materials, maximizes the utilization factor of conveyance so as to heighten efficiency and reduce cost. For instance, standardization of package for some kind of material increases about 50 % capacity of DongFeng truck and reduces more than 30 % freight.

115.3.1 Present Situation of Standard for Packaging Dimension in Transition and Dimension for Container Packaging

Container Packaging is a type of package to adapt large scale transportation and standardization of packaging dimension. It is to stack small material or cartons together in some rule, and make them to a unit to be stored, carried and transported. Since it can meet demand of storage and transportation for large scale material, most countries take this technology in logistic. Container packaging and transportation started late in China. So far, packaging dimension series to match container packaging is lacking, and cannot make full use of container space. At the same time, it compounds the difficulty of handling, increase ineffective work and reduce logistic speed.

Many enterprises do not make a standard of packaging dimension from angel of container packaging or logistic system, which makes the dimension of corrugated cartons no match the pallet. Then if using standard pallets, they cannot make sure to make full use of surface of pallets. If using made pallets, the specification of pallets is not sure to conform to standard. At the same time, this makes container stacking difficult.

115.3.2 Concepts of Coordinating Transition Packaging Dimension and Container Packaging Dimension

Currently, dimension of transition packages are different, and specification of various equipments in logistic is also varied. If we identify the dimension of inside package and transition package based on modulus series of packaging, we will get the best coordination in packaging, so as to integrate the whole process from material ex-factory, storage to application in an effective way. It will bring full play of transition packaging and heighten the effect. Moreover, if we design the dimension of transportation conveyance, handling equipment, storage equipment, goods, platform and port systems based on logistic modulus series, we will get the best coordination between packaged material and transportation equipment.

Therefore, we need to consider both transition packaging dimension and container dimension to establish a packaging modulus series. Firstly, we design container package—container box or pallet based on packaging modulus—600 mm * 400 mm, then take inside dimension of container or pallet as maximum cardinal number, times the priority fraction numerical system we chose, then we get the packaging modulus series. If we take outside dimension of container or pallet as minimum cardinal number, times the priority integer numerical system we chose, then we will get the material transportation modulus series.

"inside-outside" approach—based on material size, to design inner package, outer package and geometric packing container in turn, and select corrugated cartons according to each package, finally to put it into container. Since this way is to select outside package dimension based on inside package characters, so it has many stacking type. In handling process, we need to compare and select the stacking diagram with high utilization ratio (Mo and Hu 2008).

"outside-inside" approach—takes dimension value divided from dimension modulus series of container unit as size of corrugated cartons, inner package (or naked) goods, then select divided dimension series as outer package, and finally handle it into container. This design idea is based on specification of container unit, to design size of corrugated cartons by division way, and then combine cartons to package unit by inner packaging, finally to confirm stacking in container based on pervious division map, to handle it as container unit. The advantage of this way is, stacking map of cartons is confirmed when size of corrugated carton designing, which is easy for container handling. As Fig. 115.1 shown (Wang and Zhao 2009), package dimension in transition should match size of each equipment used in the material transportation modulus series, to improve utilization rate of equipment and efficiency of transportation.

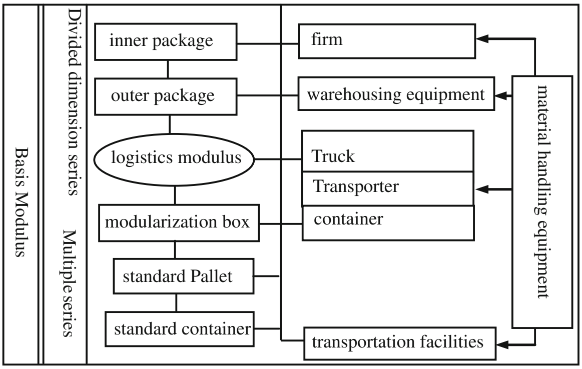

Fig. 115.1 Coordination between transport packaging and assembly packaging

115.4 Rationally Application of Transportation and Packing Information in Modern Logistic

Transportation and packing information of logistic unit is the base of information collection in modern logistic system, and the critical point to realize the visual logistic. For any logistic unit, if we get necessary transportation and packing information about it, we can complete any logistical work on it, including transportation, storage and distribution. The most common info of a logistic unit includes remark of unit, classification, recipient and shipment mark, transition and storage, recycle info of container and shipment-documentation (Ping and Yu 2005).

115.4.1 Information of Classification for Package

It's important information for transportation and package. Classification for package is to determine grades of package, according to environment, distance, turn over times, storage time and type of transition and handling. Some advanced countries classified package for military material. For instance, package for military material in UK has four grades (J, N, P and H). And USA army has two grades (A and B).

115.4.2 Recipient and Shipment Mark

It's applied to indentify goods in process of transportation. It is very important to manage receipting and shipping, Input storage and handling on trucks and vessels, and it's also the base of shipping documents, transportation insurance documents and tradition contract. Recipient and shipment mark is collectively of graphic mark of goods category, other mark and table form of words description on outer package. According to rule in GB 6388 (Recipient and shipment mark for transition package), it has 14 recipient and shipment marks and 12 graphic marks of goods category. Recipient and shipment mark is including graphic marks of goods category, supplier code, article code, name and specification, quantity, weight, producing date, original factory, physical volume, valid date, receipt name and address, deliver name, transition code and cargo numbers (Akao 1990; Hauser and Clausing 1988; Hassan and Gibreel 2000; Murray and Mahmassani 2003).

115.4.3 Graphic Mark of Storage and Transportation

According to rule of GB191-85 (Graphic mark of package, storage and transportation), in storage and transition, following standard in the rule, simple and smart graphic or word description should be marked on certain position of package, to make storage and handling proper, and improve security of storage and transition.

115.4.4 Graphic Mark of Hazardous Cargo

To focus people's special attention, graphic marks in special color or diamond-shape in black-white should be marked on some explosives, poisonous gas, flammable liquid, flammable solid, toxic materials, Grade 1 radioactive materials, Grade 2 radioactive materials, Grade 3 radioactive materials, corrosive goods and other dangerous goods during transportation. Graphic mark of hazardous cargo instructs category and dangerous grade, is only used on transition package of hazardous cargo.

115.4.5 Mark of Recycling Package

It is developed based on demand of recovering and regenerating package. The graphic mark in GB 18455-2001 is same as standard used internationally, including reusable, regenerative, regenerative material used and green marks, suitable for all kinds of recycle package (excluding hazardous material). Recycling mark of plastic package is composed of graphic, plastic material code and respective abbreviation code. Abbreviation code for plastic material follows standard in GB/T 1844.4, and situated below graphic. For plastic container or package, an intuitive mark showing recycling code of plastic type must to be printed or carved on packaging (Deng 1998; Hauser and Clausing 1988; Liu 2005; Sohail et al. 2006; Bhatnagar et al. 1999).

Inner package of hazardous material cannot be recycled. Disposable package used on medical goods cannot be reused; only can recover some regenerative material.

115.5 Conclusion

Strengthening transportation and packing information of logistic unit, can improve circulative forces and environment security. It is not only the demand of adapting modern logistic development, but also the demand of heightening efficiency of supply chain that improves the ability of management decision making and emergent response in supply chain.

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Chapter 116
Research of Mass Customization Logistics Service Supply Chain Coordination Measure Based on Entropy

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Abstract Mass customization logistics and service operations are currently the two hot research fields. In this paper, mass customization service supply chain and its model is proposed on mass customization and service operation. Entropy model is used for mass customization service supply chain system collaboration validity determination. At the same time the corresponding algorithm is proposed. Finally, example showing the entropy model can be applied to the determination of mass customization supply chain collaborative validity and put forward the corresponding coordination key technology. The conclusions of this study have certain theory significance and practical significance for modern mass customization service node enterprises in supply chain.

Keywords Mass customization · Mass customization logistics service supply chain · Entropy theory · Cooperative validity

116.1 Introduction

Mass customization, customization of products and services is the mass production; its core is the diversification of product variety and customization (Pine BJ 1993). With the development of modern enterprise competition, market personalized requirements are also getting higher and higher. In the face of modern

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logistics service quality and continuously improve the level of logistics services, mass customization logistics service supply chain is put forward with high quality, agile, flexible and innovative features is becoming more and more important. Logistics service supply chain is a kind of the structure as the core of integration, functional logistics service providers, logistics service integrator, logistics customer and service capability ensure and so on. de Waart and Steve Kremper (2004) that a service supply chain is in the products and services in the process of service planning, resource allocation, distribution and recovery process (de Waart and Kremper 2004). Akkermans study of service supply chain bullwhip effect and application case corresponding analysis (Henk and Bart 2003). Razzaque on logistics outsourcing problems were studied and the logistics service providers were classified (Razzaque and Sheng 1998). Hill provided the best method of transport for customers on the third party logistics function extended (Hill 1994). Muller firstly believed logistics service provider based on the operation of the third party logistics provider and the information of third party logistics providers (Muller 1993). Mass customization logistics service supply chain is also a hotspot.

116.2 Entropy Theory

Entropy theory of thermodynamics of the earliest origin, (1865) by the German physicist K. Clausis proposed the definition of entropy (Entropy). Entropy uncertainty is a quantitative measurement, the formula is as follows: $S = -\sum_{i=1}^{n} P_i InP_i \; P_i \geq 0, (i = 1, 2, \cdots, n), \sum_{i=1}^{n} P_i = 1$. If the system state is equal probability (Pi = 1/i), system for maximum entropy; If the system in the presence of n process subsystem, hypothetical process subsystem are independent and subsystem all process variables obey $X(X_{i,}X_{it}/N,X_{it})$. So each process system entropy $S_i = -kN\sum_{i=1}^{n} P_i(t)InP_i(t) = -kN\sum_{i=1}^{n} \frac{n_i(t)}{N} * In\frac{n_i(t)}{N}$; By relating the entropy computing principle, we can much easily draw the system entropy

$$SS_i = \sum_{i=1}^{n} S_i = -kNEIn\prod_{i=1}^{n} P(\varepsilon_i(t) = -kN\sum_{i=1}^{n} EIn(P(\varepsilon_i(t)));$$

If $SS_1 \leq SS_{2,}$, System coordination degree did not reduce. Conversely, if $SS_1 > SS_{2,}$, system coordination degree did reduce. To sum up the theory of entropy can be well applied in the quantitative determination of the extent of system coordination.

116.3 Mass Customization Logistics Service Supply Chain

Mass customization (MC) meets the demand of customer in personalized and maintains a low cost and high efficiency is an effective combination of customization production and mass production is an advanced production mode. As the supply chain node enterprises establish strategic cooperative partnership, achieve information sharing, reducing intermediate links costs, and finally realize the maximization profit requires mass customization supply chain. Jianming Yao, LiwenLiu solved the mass customization supply chain scheduling main based on previous research foundation, contradiction. Construction dynamic multi-objective optimization mathematical model and its corresponding algorithm (Yao and Liu 2009). Henry Aigbedo proposed mass customization effect evaluation under the mode of JIT supply chain, mass customization inventory levels requires suppliers to pay attention to inventory of every variable to prevent shortage (Henry 2007). Olivier Labarthe, Bernard Espinasse establish the frame of Mult-agent model and the simulation experiment based on Mult-agent modeling under the environment of mass customization (Olivier et al. 2007). M. Ghiassia, C. Spera defines mass customization supply chain system based on Internet, generally provide the Internet accelerated mass customization productsfrom computers to car product (Ghiassia and Spera 2003). P.T. Helo, Q.L. Xu, S.J. Kyllo. Nen, R.J. Jiao is proposed mass customization configuration system based on the vehicle (Helo et al. 2010). Waart and Kemper define service supply chain to support enterprise products after sale service related to material planning, all the logistics process and activity (de Waart 2004). Youngdahl, Loomba research on global supply chain service and sale services (Youngdahl and Loomba 2000). The paper defined mass customization service supply chain according to mass customization, supply chain, service supply chain research. From the logistics service and logistics service delivery process angle, mass customization logistics service supply chain: From the customer needs, in order for the standard, by logistics service integrator according to customer demand, suppliers, logistics service integrator and transforming it into the core of logistics services to the customers, finally to process of a network structure meeting customer demand. Mass customization logistics service supply chain is the logistics process integration to meet customer logistics demand. Mass customization logistics service supply chain concept model based on mass customization logistics service supply chain, Ellram model, IUE-SSCM model and SSCF model and research into customer, duality, internal logistics service supply and logistics service supply chain, As is shown in Fig.116.1:

Mass customization service supply chain is a complex, functional chain structure. Mass customization supply chain services have the following characteristics: (1) Dynamic response customized orders. Mass customization supply chain is a dynamic structure changing along with the order and mass customization enterprises operating environment. Modern enterprise management should constantly adjust service concept by the standards of orders and the demand of customers in the fierce market competition such as their business decision, suppliers,

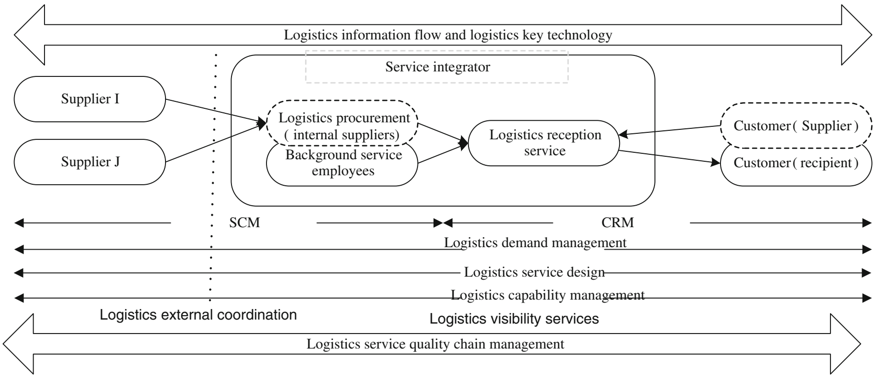

Fig. 116.1 Mass customization logistics service supply chain concept model

foreign manufacturers and other partners; (2) Anticipatory control. Mass customization supply chain management combined with mass customization modular, flexible service product characteristic and considering CPk and control limits, so the whole mass customization service supply chain process achieve synergy anticipatory control; (3) Coordination. Mass customization services chain management process covers the mass customization service supply chain node, the whole control process is collaborative process of logistics services; (4) Breaking the enterprise boundary. In the conditions of economic globalization, the service product formation and Realization of process has been completely broke the single enterprise boundaries, extends to the mass customization service supply chain enterprise group. In conclusion, mass customization supply chain management with orders for the main line, to customers as the center of the dynamic, collaborative logistics service management system, mass customization service supply chain management, is the development trend of the service operation.

116.4 Mass Customization Logistics Service Supply Chain Collaborative Validity Analysis Based on Entropy

Mass customization logistics service supply chain coordination mechanism analysis can use entropy according to the definition of mass customization logistics service supply chain, as well as more entropy correlation analysis. It can be constructed the mass customization logistics service supply chain model based on the entropy. Mass customization logistics service supply chain model based on entropy as shown in Fig. 116.2:

When supply chain enterprise in the mass customization logistics services all members is the ideal cooperative state, the system entropy is the minimum, i.e. system entropy:

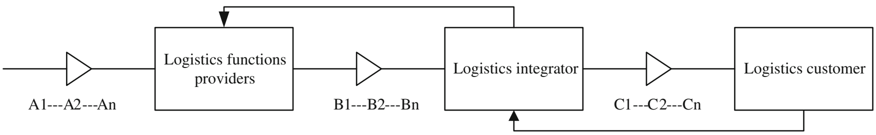

Fig. 116.2 Mass customization logistics service supply chain model based on entropy

$$\min SS_i = \min \sum_{i=1}^{n} S_i = \min(-kNEIn \prod_{i=1}^{n} P(\varepsilon_i(t)) = \min(-kN \sum_{i=1}^{n} EIn(P(\varepsilon_i(t))))$$

When fully ideal state, system entropy is 0. Mass customization logistics service supply chain complexity with the system entropy is proportional, and coordination efficiency is inversely proportional logistics service supply chain system entropy reduction is effected by the complexity of their management and enhancing collaborative efficiency. In conclusion it can reduce the mass customization logistics service supply chain system entropy by improving the mass customization logistics service supply chain collaborative quality management level. Coordination mechanism analysis based on entropy theory. Mass customization logistics service supply chain collaborative problem (Hennet and Yasemin 2008; Chiu and Lin 2004) can be analyzed from the dynamic to static, but also enterprise analyzed its process and overall coordination from internal to external entropy. Mass customization logistics service supply chain is the standard dynamic network structure such as time, space, environment of Ministry of inside and outside, member enterprises, custom element, so we can analyze from the internal mechanism fully coupling by use of entropy theory. Mass customization logistics service supply chain system entropy can be express mathematical formulas as follows: $d = \sum_{i=1}^{n} d_i + \sum_{i=1}^{n} d_o$ d_i is the system internal entropy, d_o is the external system entropy. Cooperation controlling conditions of the member enterprise for each node: $\min d = \min(\sum_{i=1}^{n} d_i + \sum_{i=1}^{n} d_o)$. When d $\leq$ 0 mass customization logistics service supply chain enterprises is coordination; When d $>$ 0, mass customization logistics service supply chain is in a chaotic state. If the control theory, coordination theory and the theory of chaos and its combined model for mass customization logistics service supply chain stochastic regularity, select the appropriate control coordination variables can put coordination variables control to a better order standard range. According to the theory of entropy, if in an ideal system in the closed state, and without any means of control, its evolution direction slowly towards mass customization logistics service supply chain system disordered equilibrium, So mass customization logistics service supply chain inside exists the deformation process and phenomenon, which leads to the system inevitably increasing degree of disorder, the degree of cooperativity decrease, the final order standard cannot be achieved.

116.5 The Example

Mass customization logistics service supply chain coordination containing each node logistics, workflow, information flow, value flow coordination problem. Mass customization logistics service supply chain coordination analysis based on its system entropy, information entropy as an example and by the use of joint entropy and conditional entropy. Assuming mass customization logistics service supply chain function provider for A; logistics integrator for the C client for B, in the calculation process, all valid data are dimensionless processing. Mass customization logistics service supply chain nodes logistics (RTYstandard) expressed as shown in Table 116.1:

Mass customization logistics service supply chain nodes information flow (with valid information for standard) can be expressed as shown in Table 116.2:

Mass customization logistics service supply chain system entropy calculation procedure is as follows:

Step 1: Using probability formula

$$P(a_i) = \sum_{i=1}^{l} p_i;\ P(b_j) = \sum_{j=1}^{m} p_j;\ P(c_k) = \sum_{k=1}^{n} p_k$$

calculation mass customization logistics service supply chain nodes of A, C, B probability.

Step 2: application of conditional probability $P(b_j|a_i) = P(a_i, b_j)$, $P(c_k\big|a_i, b_j) = .P(c_k|a_i)P(c_k\big|b_j)$ Calculation of mass customization logistics service supply chain nodes of A, C, B conditional probability.

Step 3: According to the joint probability formula $P(a_i, b_j, c_k) = P(a_i)P(b_j|a_i)$ $P(c_k\big|a_i, b_j)$

Calculation of the mass customization logistics service supply chain nodes of A, C, B joint probability.

Step 4: According to mass customization logistics service supply chain joint probability

$$SS_i = \sum_{i=1}^{n} S_i = -kNEIn \prod_{i=1}^{n} P(\varepsilon_i(t) = -kN \sum_{i=1}^{n} EIn(P(\varepsilon_i(t)))$$

Table 116.1 Mass customization logistics service supply chain logistics example

MC logistics service supply chain node	I	II	III	IV
A_1	99	85	90	80
C_1	90	70	85	75
B_1	85	65	80	70

Table 116.2 Mass customization logistics service supply chain node information flow example

MC logistics service supply chain node	I	II	III	IV
A_2	30	20	25	35
C_2	40	30	35	40
B_2	20	15	16	25

Table 116.3 Entropy based mass customization logistics service supply chain collaborative validity of numerical

Logistics service supply chain node	SS_1	SS_2	SS_3	SS_4	$\sum SS$
A_1	0.1597	0.1577	0.1588	0.1653	0.6415
C_1	0.1598	0.1555	0.1595	0.1648	0.6396
B_1	0.1598	0.1551	0.1596	0.1905	0.6650
$\sum SS_i$	0.4793	0.4682	0.4779	0.5207	1.9461
A_2	0.1592	0.1531	0.1590	0.1905	0.6618
C_2	0.1597	0.1555	0.1590	0.1213	0.5955
B_2	0.1594	0.1563	0.1580	0.2189	0.6926
$\sum SS_i$	0.4783	0.4648	0.4760	0.5307	1.9498

Calculation of the mass customization logistics service supply chain system entropy

$$S(a_i, b_j, c_k) = -\sum_{i=1}^{l}\sum_{j=1}^{m}\sum_{k=1}^{n} P(a_i)InP(a_i)P(b_j|a_i)InP(b_j|a_i)P(c_k\big|a_i, b_j)InP(c_k\big|a_i, b_j)$$

Through mass customization logistics service supply chain example program the paper draws the related data are as follows (K = 1) are shown in Table 116.3:

So the mass customization logistics service supply chain system entropy S1 (AI, Bi, CI) = 0.4788; S2 (AI, Bi, CI) = 0.4665; S1 (AI, Bi, CI) = 0.4769; S4 (A4, B4, C4) = 0.5257.

116.6 Conclusion

By research of entropy theory model and the system state model to mass customization logistics service supply chain coordination mechanism in this paper can be drawn: mass customization logistics service supply chain collaborative validity decline is composed of system entropy increasing causes. So the use of entropy principle of potential energy and the cooperative principle to enhance the core competitiveness of enterprises, the correct and effective introducing negative entropy flow to reduce mass customization logistics service supply chain system entropy is the key to solve the collaborative management benefit decreases. In conclusion, mass customization logistics service supply chain management is a member enterprise cooperation and orders the implementation as the goal, through the collaborative process (critical node of logistics, workflow, information flow, value flow coordination control and Optimization), collaborative improvement improve collaboration among member enterprises degree by reducing logistics entropy, entropy, information entropy, the entropy value. The paper recommendations the design mass customization service supply chain collaborative intelligent system for the LSSC oriented. According to mass customization service node enterprises in supply chain practice, based on the metadata driven thought, the paper detailed analysis the LSSC-BIS mass customization service supply chain structure design, constructing of the LSSC mass customization supply chain information platform for mass customization, the service node enterprises in supply chain data collection, collation and analysis, mass customization service supply chain node enterprises to provide accurate, effective information and knowledge, which improve the mass customization service supply chain logistics service quality level has been a certain practical value. Mass customization logistics service supply chain coordination mechanism has both practical and theoretical significance, using entropy theory model and process of the system state model, combined with mathematical prediction model and its algorithm for mass customization logistics service supply chain system collaboration mechanism and quantitative prediction is one of the important research topics of our future.

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Chapter 117
Research on Business Model of Internet of Things Based on MOP

Huan Li and Zheng-zhong Xu

Abstract The Internet of things will drive the whole community from the binary model of human society–physical world to the triple model of human society–information space–physical world. In contrast with the hot concept, the business model of the Internet of things is quite vague, which will block the development of Internet of things. Firstly, we review the concept, technology framework and industry situation of Internet of things; secondly, from summarizing the definitions of business model, we definite the business model of Internet of things as a multidimensional structure composed of technology dimension, industry dimension, policy dimension and strategy dimension. Thirdly, we try to construct a multiple open platform model to achieve the business model of Internet of things.

Keywords Business model · Industrial chain · Internet of things (IOT) · Multiple open platform (MOP) · Technology

117.1 Overview of Internet of Things

A series of hot words like "the wisdom of the earth", "the perception of China", "ecological community" and so on have pushed Internet of things (IOT) into the center of economic reform, technology innovation and social promotion since 2009. Any development of a technology or an idea must experience the processes of occurrence and expanding, and then enter the climax period, the same as the IOT. After experiencing the germination stage, under the governments' impulse, the IOT has attracted the attention of the whole world and enter the climax stage.

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117.1.1 The Concept of IOT

After the computer revolution and the internet revolution, the IOT has caused the third information technology revolution, extending the interaction from the humans to the objects. In essence, the IOT is not a new concept, some highly relevant concepts like "sensor network" and "M2M" have been existent for a long time. As a special noun, the IOT has been recognized since 2005, but hasn't a uniform definition till now. ITU said that the IOT meant "from anytime, any place connectivity for anyone, we will now have connectivity for anything (International Telecommunication Union (ITU) 2005)". Although there are many different concepts now, they all embody the four "A"s—"anytime", "any place", "anyone" and "anything". In China, the Ministry of industry and information published the white paper defined that "the IOT is the application development and network extension of the communication networks and Internet. It uses the sensing technology and intelligent devices to the physical world for perception and identification. Through the network transmission of Internet, calculation, processing and knowledge mining, it realizes the Information interaction and seamless link between person and matter as well as mater to mater, and achieves real-time control, precise management and scientific decision to the physical world (China Academy of Telecommunication Research of MIIT 2011)".

117.1.2 Technologies of IOT

In general, the IOT is not a single technology. It contains a set of technologies which can be divided into three layers: the perception layer, the network layer and the application layer (Xiang 2010).

Perception is the first step from the physical world to information space. Like person's sense organ, the perception technologies recognize the objective things and collect data to transmission, so they mainly refer to data recognition and acquisition technologies. At present, the two-dimensional code technology, card technology and RFID are relatively mature, accounting for the mainstream. What's more, the research and development of the chip technology which can drive various types of sensing device is the trend for future.

Network refers to the virtual platform of the information receiving, dissemination and sharing. The network layer to the IOT like the transmission nerve to a person, it's responsible for the information communication and path controlling. This layer mainly focuses on the Internet technology and wireless network technologies like WSN, WMN, Ad hoc and so on.

Application is the goal of all technologies. After perception and transmission, the application layer will face the integration, analysis, mining, storage and application of data. The application layer technologies include public technology and industry technology. Public technology mainly refers to the artificial

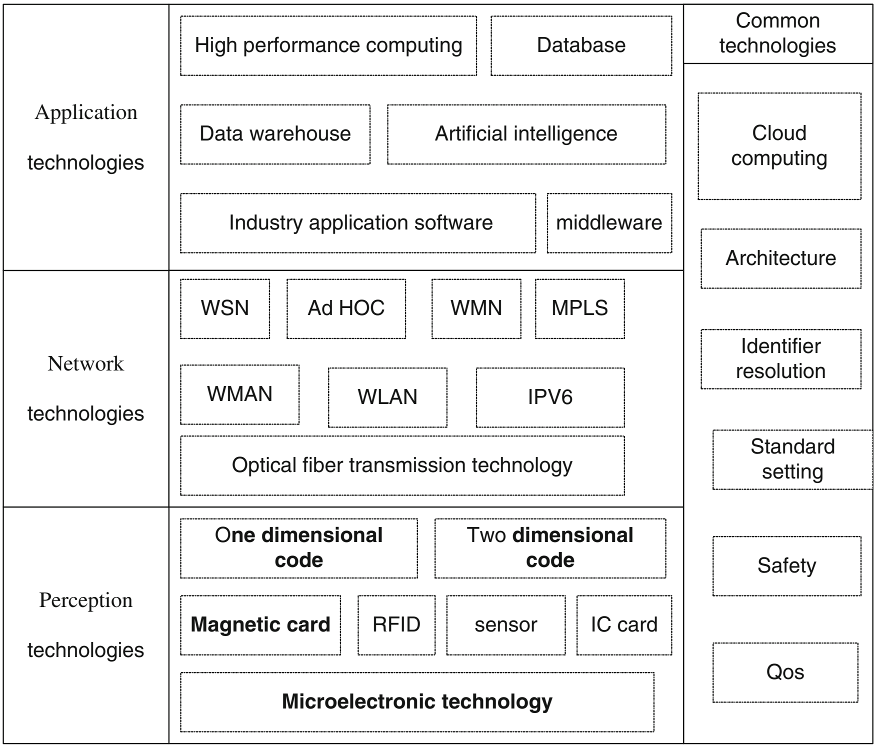

Fig. 117.1 Technology structure and critical technologies of IOT

intelligence technology, mass data storage technology, data mining and analysis techniques, high performance computing technology, GIS/GPS technology and so on, and industry technology mainly relate to specific works which put forward great demand to the middleware technology.

Besides, there are some common technologies which throughout the three layers like cloud computing, architecture technology, safety technology and so on (Fig. 117.1).

117.1.3 The Industry Development of IOT

The IOT can be used in public security, city management, ecological environment, traffic management, agriculture, health, culture and other fields, become a large scale industrial cluster. The authority institution Forrester in America predicted that to 2020, the ratio of "objects interconnection" and "human communication" would reach 30:1, and would reach 100:1 even 1000:1 in the future and became a trillion level industries. So the industry of IOT has been called a trillion cakes (Zhou 2010).

But In contrast with the hot concept, the business model of the IOT is quite vague, which will impede the development of the whole industry (Zhang 2010). Based on the technology structure, the industry chain was composed of perception nodes, transmission nodes, middleware and application nodes and the integration nodes. Industry alliance is the main form of industry chain, and the operator play the role of dominant, the strength of the overall manufacturers is weak. Designing an effective business model for IOT to improve the whole industry is very important and necessary right now.

117.2 The Connotation of Business Model of IOT

Business model has been integral to trading and economic behavior since pre-classical times (Teece 2010), but it's in the mid 1990s that the concept of business model became prevalent with the advent of the Internet, and since then, it has been gathering momentum. Surprisingly, different scholars have different definitions of the business model in different areas. Chesbrough and Rosenbloom said that "the business model is the heuristic logic that connects technical potential with the realization of economic value (Chesbrough and Rosenbloom 2002)". Teece said that "a business model articulates the logic, the data and other evidence that support a value proposition for the customer, and a viable structure of revenues and costs for the enterprise delivering that value (Teece 2010)". Casadesus Masanell and Ricart defined it as a reflection of firm realized strategy (Casadesus Masanell and Ricart 2010).At a general level the business model has been referred as a statement (Stewart and Zhao 2000), a description (Applegate 2000), a representation (Mirris et al. 2005), an architecture (Timmers 1998), a structural template (Amit and Zott 2001), a set (Seelos and Mair 2007), a pattern (Brousseau and Penard 2006) and so on. However, the business model has been mainly employed in trying to address or explain three phenomena: (1) technology and innovation management; (2) strategic issues, such as value creation, competitive advantage, and firm performance; (3) e-business and how to use information in organizations.

Considering the above business model definition, we think that the business model should be a bridge between the technology and economy, which can guarantee the sustainable development of the industry. Microscopically, it can promote the development of an enterprise; macroscopically, it will promote the progress of the whole industry. As for the business model of the IOT, we prefer the latter. It should represent a pattern, a structure, which can facilitate the transformation and application of the IOT. It should not only help the relative enterprises to make money, but also can realize the real development of the industry, instead of hovering in the infinite imagination of the concept and industry.

The business model of IOT should be a multidimensional structure composed of technology, industry, strategy and policy latitudes. In the technology dimension, it should include the research, innovation and application of technologies; in the industrial dimension, it should pay more attention on the realms in which the IOT can enter, and designing the proper industry chains; in the strategy dimension, it will do more research on the strategic issues such as competitive advantage, value chain, value net and so on; in the policy dimension, for making the technology, industry and strategy into truth, this dimension will set up some policies like financial policy and finance policy in time to ensure the actualizing of other dimensions.

The intersection and integration of each dimension can reflect the business model of IOT. Constructing a multiple open platform is a method to put the business model into practice (Fig. 117.2).

117.3 The Multiple Open Platform Model

As shown in Fig. 117.3, based on the connotation of the business model of IOT above, we can construct a multiple open platform (MOP) model to realize it. Accordingly, we can build technology research platform, industry sharing platform, public service platform, and strategic alliance platform and let the four platform couple to each other, put the official, the industry, the universities, the research institutions, the financial, and the entrepreneurship together, form a MOP.

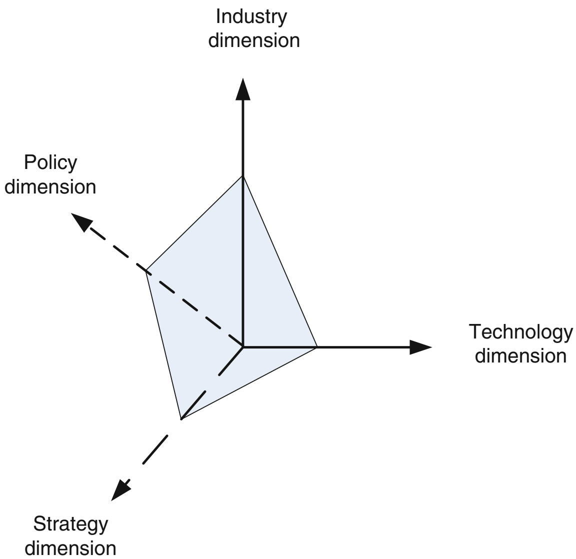

Fig. 117.2 Multidimensional structure of business model of IOT

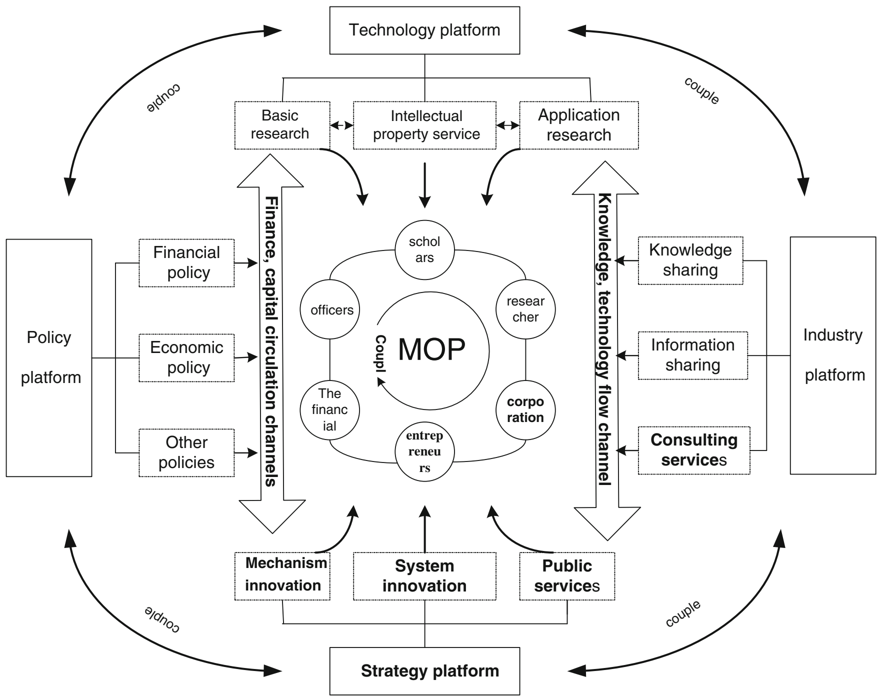

Fig. 117.3 MOP model

117.3.1 The Technology Platform

The IOT is not a single technique, but a collection of techniques, involving almost each aspects of information technology, which causes the unbalanced development of the IOT. In the technology platform, the scholars and the researchers can talk in a unifying platform, different technologies can be managed together, in the mean time, some advisory services like intellectual property and technology transfer can be provided. The platform is useful for forming the architecture of IOT and conducive to constitute the standards, which can help to overcome the technical bottleneck of IOT at present.

117.3.2 The Industry Platform

This platform mainly aims at the enterprises to ameliorate the chaos and unbalanced development of the industry chain. Jiang Guoyin published a paper proved that it was the interest community that can realize the maximize profits (Jiang et al. 2010). In the industry platform, the enterprises can share the common information and discuss the common issues of them. At the same time, the platform can provide legal, technology, management and other public services, so as to achieve the maximum profits of the industry chain.

117.3.3 The Policy Platform

Policy reflects the confidence and determination of a country for an industry. To ensure the rational development of the whole industry, the country needs to design at the top layer, rather than allowing the act of one's own free will. Specially, the policies contain the state policy, local policy, financial policy and so on. The platform provides a chance to link the officials to other relative experts.

117.3.4 The Strategy Platform

This platform will coordinate the other three platforms and integrate them. For one thing, some common business which can't be involved in other platform such as the infrastructure construction can be discussed in this platform; for another, the platform mainly pays attention to the innovation of system and mechanism.

Generally speaking, the MOP is an information sharing platform, a technology diffusion platform, a talents gathering platform, a creative derivative platform and a public service platform. The MOP will get through financial, capital channel, incorporating different talents, make the IOT technology commercial, and finally achieve the IOT strategy.

117.4 Conclusion

After the computer revolution and the internet revolution, the IOT arise the third information technology revolution, extending the interaction from the humans to the objects. It will drive the whole community from the binary model of human society- physical world to the triple model of human society–information space–physical world.

China has had an advantage in the field of some related technologies and standards. What's more, relying on large numbers of population and cell phone nodes, China has attracted much attention in the IOT area. But the lack of business model has become one of the main factors obstructing the development of IOT. We prefer that the business model of IOT should be a multidimensional structure composed of technology dimension, industry dimension, policy dimension and strategy dimension. And constructing a MOP which can link the officers, entrepreneurs, scholars, researchers and the financial together is an effective mean to achieve the business model of IOT.

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Chapter 118
Research on Control of Passing Priority in Logistics Nodes Among the Distribution Centers

Wen-xue Ran, Dong-feng Zhao and Zhi-wei Wang

Abstract In this article, we adopt the Markov Chain theory and Probability generating functions as analysis and study of the function methods. With complete service rules and limited rules constructed passing ability and control analysis model of logistics nodes of distribution center. From the mean waiting time of through passing logistics nodes to analyze out its control of the priority and presents the corresponding simulation experiment results, research and analysis of the conclusion.

Keywords Logistics nodes · Mean waiting time · Priority classes · The passing ability

118.1 Introduction

Distribution center is the result of highly social civilization and large-scale economic development, with consumer demand for the center (Zhao 1988).

The modern distribution center, they need not only reasonably low cost, more importantly, pursuit of high efficiency, to better meet the needs of the scale.

Logistics node is distribution center business place of crisscross, and especially important link of conveying special requirements for the order such as having number, order, points and single, time points etc. it is the most common and indispensable link in distribution center, also is the key place which influences the

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efficiency of the logistics (Boon et al. 2011). The high efficiency of order in the passing ability of logistics nodes, it is one of the key factors of high efficiency to determine logistics system. So, in automatic logistics conveyor system, scheduling and control of the node logistics, especially on the order conveying, become a key of measuring system control levels. Of course, the effective control and scheduling of logistics nodes are able to improve the efficiency of the logistics conveyor system (Boxma et al. 2009).

In this article, we adopt the Markov Chain theory and Probability generating function as analysis and study of the function methods (Zhang et al. 2008), by establishing model, analyzing priority of passing ability of logistics nodes in distribution center, thereby reveals the core mechanism of its process control, to provide the theory basis for refine control and scheduling of efficient logistics conveyor system (Zhao et al. 2010; Yang and Zhao 2008).

118.2 Research Model of the Passing Ability of Logistics Nodes

There are many forms of logistics nodes, as shown in Fig. 118.1.

Having two logistics order *I* and *II*, needing to pass the logistics nodes in any time period. Assuming average number of goods in order *I* as $\alpha_1 = A_1'(1)$, probability generating function of the order *I* to logistics nodes is $A_1(z_1)$ the average time of the order *I* goods through logistics nodes is $\beta_1 = B_1'(1)$, probability generating function of time through the logistics nodes is $B_1(z)$. Also, assuming average number of goods in order *II* as $\alpha_2 = A_2'(1)$, probability generating function of the order *II* to logistics nodes is $A_2(z_2)$, the average time of the order *II* goods through logistics nodes is $\beta_2 = B_2'(1)$, probability generating function of time through the logistics nodes is $B_2(z)$.

Logistics nodes from the first item of order *I* began to pass, goods of order *I* and order *II* which are going through, theirs probability generating function of State equation is (Liu and Zhao 2009; Bao et al. 2010; Borst and Mei RD 1998; Bhuyan et al. 1998)

$$G_1(z_1, z_2) = G_2\{z_1, B_2[A_1(z_1)F(A_1(z_1))]\} \tag{118.1}$$

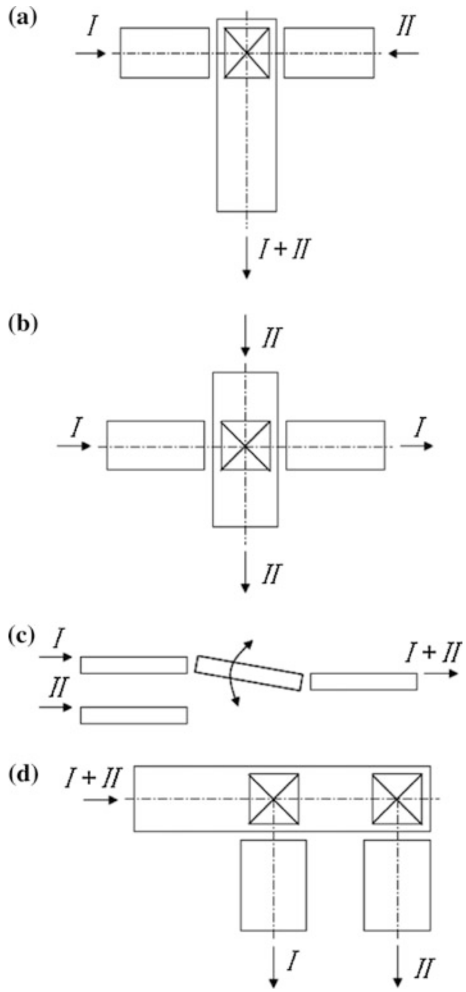
where

$$F(z_1) = A_1(B_1(z_1F(z_1)))$$

$$F(z_2) = A_2(B_2(z_2F(z_2)))$$

After logistics nodes through the first item of order *I*, theirs probability generating function of State equation is

Fig. 118.1 Logistics nodes Schematic plot



$$Q_1(z_1, z_2) = \frac{1}{C_1 z_1} B_1[A_1(z_1)A_2(z_2)][G_1(z_1, z_2) - G_1(0, z_2)] \tag{118.2}$$

where $C_1 = 1 - G_1(0, 1)$.

The sojourn time (processing time + waiting time) of item in order I, theirs probability generating function of state equation is

$$W_1(A_1(Z_1)) = Q_1(z_1, 1) = \frac{1}{C_1 z_1} B_1[A_1(z_1)][G_1(z_1, 1) - G_1(0, 1)] \tag{118.3}$$

When the first item of order II gets through logistics nodes, goods of order I and order II which are going through, and their probability generating function of state equation is

$$G_2(z_1,z_2) = \frac{1}{z_1} B_1[A_1(z_1)A_2(z_2)][G_1(z_1,z_2) - G_1(0,z_2)] + A_1(z_1)A_2(z_2)G_1(0,z_2) \tag{118.4}$$

After logistics nodes through the first item of order *II* their probability generating function of state equation is

$$Q_2(z_1,z_2) = \frac{B_2[A_1(z_1)A_2(z_2)]}{C_2[z_2 - B_2(A_1(z_1)A_2(z_2))]} \{G_2(z_1,z_2) - G_2[z_1, B_2(A_1(z_1)F(A_1(z_1)))]\} \tag{118.5}$$

where $C_2 = \frac{1}{1-\alpha_2\beta_2}\left[\lim\limits_{z_1,z_2\to 1} \frac{\partial G_2(z_1,z_2)}{\partial z_2}\right]$

Sojourn time (processing time + waiting time) of item in order *II*, theirs probability generating function of state equation is

$$W_2(A_2(Z_2)) = Q_1(1,z_2) = \frac{B_2(A_2(Z_2))}{C_2[z_2 - B_2(A_2(Z_2))]}[G_2(1,z_2) - 1] \tag{118.6}$$

118.3 The Solution of Steps and Results

First, probability generating function of state Eqs. (118.1–118.5), their partial derivative is

$$g_i(j) = \lim_{\substack{z_1\to 1\\ z_2\to 1}} \frac{\partial G_i(z_1,z_2)}{\partial z_i} \tag{118.7}$$

Second, solving state equation of probability generating function, their two order partial derivative is

$$g_i(j,k) = \lim_{\substack{z_1\to 1\\ z_2\to 1}} \frac{\partial^2 G_i(z_1,z_2)}{\partial z_i \partial z_k} \ (i = 1,2; j = 1,2; k = 1,2) \tag{118.8}$$

Third, the results of the above $g_i(j), g_i(j,k)$ substitute into type 3 and type 6, then we can get average sojourn time equation of item in order *I*

$$E(w_1) = \frac{1}{2|(1-\alpha_1\beta_1-\alpha_2\beta_2)||(1-\alpha_2\beta_2)|}\left\{(1-\alpha_2\beta_2)^2\frac{A_1''(1)}{\alpha_1^2} + \alpha_2^2\beta_2^2\frac{A_2''(1)}{\alpha_2^2} + \alpha_1 B_1''(1) + \alpha_2 B_2''(1) + 2\alpha_2\beta_2|(1-\alpha_2\beta_2)| + \beta_1\right. \tag{118.9}$$

At the same time, we can get average sojourn time equation of item in order

Table 118.1 Performance assessment form of the logistics node passing ability

No.	i	α_i	$A_i''(1)$	β_i :min	$B_i''(1)$	$E(w_i)$
1	I	1	1	3	9	3.129
	II	2	4	4	16	7.000
2	I	3	9	5	25	5.423
	II	2	4	4	16	10.714
3	I	10	100	20	400	21.053
	II	10	100	20	400	40.103
4	I	3	9	20	400	21.585
	II	20	400	3	9	14.703
5	I	20	400	3	9	3.990
	II	3	9	20	400	31.703
6	I	4	16	30	900	31.131
	II	4	16	30	900	60.256

$$E(w_2) = \frac{1}{2|(1-\alpha_2\beta_2)|}\left\{\frac{A_2''(1)}{\alpha_2^2} + \alpha_1 B_1''(1) + +\alpha_2 B_2''(1)\right\} + \beta_2 \tag{118.10}$$

118.4 Results

According to the results, we can set passing ability parameters two groups of orders in logistics nodes, conduct the theoretical calculation and computer simulations, the calculation results are shown in Table 118.1. Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar.

118.5 Discussion

In Table 118.1, the data of group 1 and 2 are randomly wrote, showing itself obviously, the simpler the composition of goods in the order is, the shorter sojourn time of the order is. It means that the passing ability of logistics nodes is better. In group 3, assuming that composition of order are all the same, and average time through the logistics nodes are also the same, but sojourn time through the logistics nodes are unlike. In practical applications, if order *I* and *II* arrive simultaneously, order *I* gets through firstly; it can save the time of system. (Hashida 1972; Ferguson and Aminetzah 1985).

In group 4, if the composition of order *I* is simple, and average time through the logistics nodes is 20 min, although the sojourn time are little more than the average time, compared with order *II* in group 4, it is not suitable that order *I* gets through firstly. The composition of goods in the order *II* is more complex, but mean transit time is very low, so even if the sojourn time is 4 times the mean transit time, the system still thinks that the efficiency of order *I* in group 4 getting through the nodes is higher. Order *I* and *II* in group 5, we once assume that they are extreme data, the composition of commodity in the order I is complex, but average time through the logistics nodes is short, the sojourn time of system is also short (Han et al. 2006). Composition of order *II* in group 5 is simple, but average time through the logistics nodes is long, the average sojourn time is still very long. In group 6, if the composition of order *I* and *II* is simple, their average time through the logistics nodes is the same but very long. In this scenario (Stephan 2003; She et al. 2009), the passing ability of order *I* is the best, then, the average sojourn time is short, but the average sojourn time of order *II* is twice order *I*.

118.6 Conclusion

In the practical applications of specific and automatic logistics conveyor system, the transportation of orders has three ways: (1) Simply and artificially assumes that the transmission of an order has priority. (2) Human determines who has the priority to get through the logistics nodes according to the size of the order. (3)According to the length of average time that the orders get through the logistics nodes, human decides who has the priority to get though the logistics nodes, and asks an arbitrary control of orders which have priority to get through the logistics nodes. Based on the results of this study, the three orders of transportation are not comprehensive to the passing ability of logistics nodes, and the research solution provided in this paper is more scientific and reasonable.

High efficiency of the order processing is a sort of factors which influence high efficiency of distribution center. How to scientifically and refinedly control the transportation of ordered goods and reduce the overlap time in each step can effectively improve the efficiency and the speed of order sorting. Calculation method this paper mentioned also can be used in the refined control and scheduling work such as the single and combined orders in the logistics system.

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Chapter 119
Research on Development Path of Low-Carbon Logistics Based on Principal Component Analysis

Yuan Li and Hai-ying Zhang

Abstract Nowadays climate has been deteriorated seriously which effects human survival and economic development. Developing low-carbon economy has become the common consensus of every nation to deal with the climate change. Logistics plays an important role in low-carbon economy, so the development of low-carbon logistics in logistics industry is an active promotion of low-carbon economy and a positive behaviour to environmental improvement of human being. This paper discusses the base of low-carbon logistics development, uses principal component analysis method to research the evaluation index and extracts the main factors which could help to use fewer variables instead of the original variables to solve problems. It also analyses the carbon emission and proposes implementing ways and developing path of low-carbon logistics which means to provide strategic references for the low-carbon logistics development.

Keywords Development path · Forest carbon sink · Low-carbon logistics · Principal component analysis

119.1 Introduction

With the growing of global population and economy scale, people have recognized the environmental problems caused by acid rain, chemical fumes and carbon dioxide. Among the wide range of problems facing our world today, there is a global consensus that greenhouse gas (GHG) emissions have the largest negative impact on our environment (Linden 2007). Over the past 150 years, the last decade

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was recorded to be hottest, while 2005 has been claimed to be the hottest year of the last 150 years (Schneider 1989). People begin to find a way for the human development. In order to develop low-carbon economy, on one hand, we should take environmental protection responsibility and struggle to complete the requirements of national energy saving target; on the other hand, we should adjust economic structure to enhance the energy efficiency, develop new industry and build an ecological civilization. This is a certain win–win choice for the realization of economic development and environmental protection.

Low-carbon economy is raised by the case of global warming's strait challenge to human survival and development which is the general term of a class of economic structures such as low-carbon development, low-carbon industries and low-carbon technology. Low-carbon logistics is an important part of low-carbon economy. It initiates to implement the concept of scientific development and due with the global climate change, so it takes a special status in low-carbon economy. Logistics as a high-end service must take the low carbonization path and focus on the development of green logistics services, low-carbon logistics and intelligence information (Srivastava 2007).

119.2 Methodology

The central idea of principal component analysis (PCA) is to reduce the dimensionality of a data set consisting of a large number of interrelated variables, while retaining as much as possible of the variation present in the data set. This is achieved by transforming to a new set of variables, the principal components (PCs), which are uncorrelated, and which are ordered so that the first few retain most of the variation present in all of the original variables (Jolliffe 2002). Application of the signal analysis to controllability and observability leads to a coordinate system in which the "internally balanced" model has special properties (Moore 1981).

Principal component analysis, introduced in statistics by Hotelling (1933), will be used together with the algorithm by Golub and Reinsch (1970) for computing the singular value decomposition of matrix. Dempster (1969) gives an excellent geometric treatment of principal component analysis as well as an overview of its history. A thorough discussion of the singular value decomposition and its history is given by Klema and Laub (1980).

119.2.1 Description of Evaluation Indexes

The background of low-carbon logistics is coping with global climate change. Low-carbon logistics is based on the scientific development concept, low-carbon economy, the logistics management theory and so on. Its basic requirements are energy conservation and emission reduction which will restrain logistics on the environmental pollution, reduce resource consumption and use advanced low-carbon techniques to plan and implement low-carbon logistics activities. Evaluation indexes include financial and cost index, business operation index, customer service index, research and innovation index, emission reduction environmental index.

(1) Financial and cost indexes: the total return assets, asset-liability ratio, total asset turnover, profit growth rate, quick ratio, sales growth rate, transportation costs, costs of human resources, information costs, environmental costs and inventory costs.
(2) Business indexes: response rate, punctual transportation rate, low-carbon information sharing rate, information flow rate, transmission error rate, sales ratio of industrial enterprises and production flexibility.
(3) Customer service indexes: recognition degree, customer complaint rate, time to resolve customer complaints, customer turnover rate, on-time delivery rate and return costs.
(4) Research and innovation indexes: R&D investment rate, R&D investment rate of return, the ratio of increasing about low-carbon products and service, staff ratio of science and technology development.
(5) Emission reduction environmental indexes: energy consumption per unit of product, energy consumption per unit of output, energy saving rate, equipment utilization ratio and carbon footprint.
According to the factors which effect the development of low-carbon logistics, we choose the indexes as follows:

X_1—total social logistics (100 million yuan)
X_2—logistics demand coefficient per unit of GDP
X_3—ratio of logistics costs to GDP (%)
X_4—transportation costs (100 million yuan)
X_5—logistics investment in fixed assets (100 million yuan)
X_6—ratio of oil accounts for total energy consumption (%)
X_7—population
X_8—length of transportation line (km)
X_9—ratio of R&D expenditure to GDP (%)
X_{10}—forest coverage

The data are compiled and calculated through *China Statistical Yearbook*, *China Logistics Yearbook* and *National Logistics Operation Briefing*.

119.2.2 Data Processing, Calculation and Results Evaluation

This paper collects statistical data for nearly 11 years. It uses R2.12.0 to do the principal component analysis on effecting factors. The results are shown in Table 119.1.

Table 119.1 The importance of main components

	Standard deviation	Proportion of variance	Cumulative proportion of variance
Comp.1	2.92751089	0.857032	0.857032
Comp.2	1.06487106	0.1133950	0.9704270
Comp.3	0.41363086	0.01710905	0.987536093
Comp.4	0.26196580	0.006862608	0.99439869
Comp.5	0.18799632	0.003534262	0.997932954
Comp.6	0.11104815	0.001233169	0.999166124
Comp.7	0.06728663	0.000452749	0.999618873
Comp.8	0.05221401	0.000272603	0.9998915030
Comp.9	0.03109077	9.666361E-05	9.999882E-01
Comp.10	0.01087814	1.183340E-05	1.000000E + 00

As the general condition, it could meet the requirements that the principal components can offer at least 85 % information of the original variables (Anderson 1984). From the Table 119.1, we can see that the first three eigenvalues account for 98.7 % of total variance, so choosing the first three principal components instead of the original 10 variables can affect the most of the information and it is reasonable. Through the extraction of the factors that impact our national logistics industry low carbanization development, this paper will do a further research for the three principal component factors. Factor loading matrix is shown in Table 119.2.

The first principal component can be expressed as:

$$\begin{aligned} Y_1 = {} & 0.334X_1^* + 0.337X_2^* - 0.286X_3^* + 0.337X_4^* \\ & + 0.333X_5^* - 0.235X_6^* + 0.331X_7^* + 0.335X_8^* \\ & + 0.330X_9^* + 0.228X_{10}^* \end{aligned}$$

The second principal component can be expressed as:

Table 119.2 Factor loading matrix

	Comp.1	Comp.2	Comp.3
X_1	0.334	−0.170	
X_2	0.337		−0.211
X_3	−0.286	−0.477	0.180
X_4	0.337	−0.109	−0.156
X_5	0.333	−0.178	
X_6	−0.235	0.664	−0.256
X_7	0.331	0.203	−0.273
X_8	0.335	−0.140	0.148
X_9	0.330	0.216	−0.170
X_{10}	0.288	0.380	0.838

Note The table does not show the figures which absolute value is less than 0.1

$$Y_2 = -0.170X_1^* - 0.447X_3^* - 0.109X_4^* - 0.178X_5^* + 0.664X_6^* + 0.203X_7^* - 0.140X_8^* + 0.216X_9^* + 0.380X_{10}^*$$

The third principal component can be expressed as:

$$Y_3 = -0.211X_2^* + 0.180X_3^* - 0.156X_4^* - 0.256X_6^* - 0.273X_7^* + 0.148X_8^* - 0.170X_9^* + 0.838X_{10}^*$$

Where $X_i^*(i = 1, 2, \ldots 10)$ denotes the normalized variables. From the Table 119.2, the first principal component is determined by $X_1, X_2, X_4, X_5, X_7, X_8, X_9$. Because the loading of these seven variables are greater, so they have a compact relation with the first principal component.

In the second principal component, the loading of X_3 and X_6 are greater so they are associated with the second principal component, but their sign are different. In the third principal component variable X_{10} is greater, so it has a close relation with the third principal component. Otherwise, the first principal component contains the total social logistics, logistics demand coefficient per unit of GDP, transportation costs, logistics investment in fixed assets, population, length of transportation line and ratio of R&D expenditure to GDP which reflects the influence of assets investment and R&D status on logistics industrial low-carbon development. The second principal component contains ratio of logistics costs to GDP and ratio of oil accounts for total energy consumption which reflects the influence of energy structure on logistics industrial low-carbon development. The different sign shows that comparing with clean energy, fossil energy's costs are less lower. The third principal component contains forest coverage which reflects the influence of forest carbon sinks ability on logistics industrial low-carbon development.

From above analysis, we can conclude that the factors effecting our national low-carbon logistics development contain assets input, energy structure and carbon sinks ability.

119.3 Problems and Development Path in Low-Carbon Logistics

119.3.1 Problems in Low-Carbon Logistics Development

(1) Among the choice of transport modes, the volume of freight traffic is inversely proportional to energy consumption. The most important part in logistics industry is transportation because it consumes a lot of energy and emits a large number of carbon dioxide. One of the main reasons about global warming is the gas emitted from the fuel burning.

(2) The design of supply chain is unreasonable. At present, most of companies have not adopted comprehensive and meticulous management. Because of the deficiency in supply chain and coordination, a number of inefficient circuitous transportations and freight scheduling space–time lead the return without goods become seriously.
(3) There is no standard for storage facilities. High energy consuming buildings hinder the process for China's energy saving. According to information issued by the Ministry of Construction, more than 90 % buildings in China are not energy saving.

119.3.2 Path in Low-Carbon Logistics Development

(1) Optimize the transport routes and choose the low-consumption and high-freight transport mode. In the operation, it can optimize the transport routes to reduce transport mileage. Also it can adopt low emission transport mode like railway, shipping and any others to reduce the carbon emission directly.
(4) Strengthen asset investment, develop technological innovation and promote the use of low-carbon technologies. Logistics industry that consume a large number of energy have been responded actively to the call for low-carbon economy, developed innovation positively, promoted the use of low-carbon technology and realized low-carbon logistics.
(3) Improve the energy structure and reduce carbon emission. In china, logistics industry is mainly based on nonrenewable energy. Therefore improving the energy structure needs to build a low-carbon energy system, develop renewable energy technology and energy saving technology.
(4) Develop forest carbon sinks ability. Forest is the largest carbon pool in terrestrial ecosystem. It plays an important role in reducing carbon density and mitigating global warming. In the next 30–50 years, expansion of forest coverage is a useful measure.
(5) Play an important role of the government to make the logistics industry develops healthy by its guidance, regulation and supervision. In order to provide a guarantee for the development of low-carbon logistics, the government should formulate appropriate laws as soon as possible. For example, it can use tax instruments and market mechanisms [such as carbon tax and carbon trading mechanisms (Labatt and White 2007; Oberthur and Ott 1999)], adopt the policy like low-carbon subsidies, adjust the industrial and product policies and so on.

119.4 Conclusion

This paper researches the evaluating indexes of low-carbon logistics. By using principal component analysis we identify the main factors that impact the development of low-carbon logistics and make the evaluation model simplified. The logistics industry as one of top ten industries in reviving plan is one part of the national economy which plays an important role in promoting industrial structure, changing the development mode and enhancing the competitive strength. “Low carbon” will be a new opportunity for development, but also it should be the responsibility for all worlds’ enterprises. In the low-carbon economy, it is imperative to develop low-carbon logistics and it is the road we must to take for the sustainable development.

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Chapter 120
Research on Logistics Cost Management and Control of Commercial Union Supermarket Based on the Saving Mileage Model

Yue Zhan and Chao Wang

Abstract In the modern competitive market environment, commercial union supermarket as the leading enterprises of supermarket chains, it must go through cost reduction to improve its market competitive. This article mainly from the commercial union supermarket of the total cost of logistics, based on the basis for quantitative analysis, through the application of saving mileage model to optimize the distribution line, so as to achieve the purpose of reducing distribution costs. The results show that the model can save mileage to reduce enterprise transports distribution costs, the model for the company's transportation cost management control is feasible.

Keywords Cost management · Commercial union supermarket · Logistics costs · The saving mileage model

120.1 Introduction

The logistics cost management and control is an important content of logistics management, and is also the most fundamental question for enterprise logistics to improve the service level and improve their own competitiveness of the market. Through the logistics cost effective control, make the most use of logistics elements of the relationship between benefits back, scientific and reasonable to

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organize logistics activities, strengthen to the logistics activity process cost effective control, reduce logistics activities of the materialized labor and the consumption of narrow, so it can be effective to reduce enterprise logistics total cost, and improve enterprise economic efficiency. How to optimize their own logistics resources, how to carry on the management and decision making, in order to use minimal cost to bring the most benefits, all is one of the most important issues the logistics enterprise should be faced to. This paper will take commercial union supermarket as an example to talk about how to carry on the supermarket management and control the logistics cost.

120.2 Logistics Cost Analysis

From the macroscopic speaking, commercial union supermarket logistics cost mainly includes three parts: transportation cost, inventory cost, logistics management cost.

(1) The transportation cost. It refers to the production cost happened in the distribution process of distribution vehicle. The amount of commercial union supermarket shipping costs are including vehicle fee (labors, fuel, depreciation cost, the repairs, etc), operation indirect expenses.

(2) The inventory cost. The expenses of commercial union supermarket in the preservation of the cost of goods, in addition to including storage, the damaged, human costs and insurance and tax costs, it still includes the interest of capital stock tie up. And for the speak of storage costs, because of the logistics operation impeded lead to increase inventory costs by the formation of the interest costs, stock take fund opportunity costs, the loss of market response is slow and the formation of the damage to the costs of mismanagement, the hidden costs of logistics link costs of the rates as high as 80 % above.

(3) The logistics management cost. It refers to commercial union supermarket according to the flow rule of materials material entity, it applies the principle of management and scientific method to plan, organize, command, coordinate, supervise and control the logistics activities, and make the logistics activities generated coordinate and cooperate with the cost.

And at present, among the three logistics costs, the transportation costs of commercial union supermarket has accounted for about 50 %. And in the transportation costs,

The distribution line and transport costs between compositions of all have very big link, so only when shorting the distribution mileage, optimizing the distribution line, then it can eventually reduce the transportation costs, thus reducing its cost expenses.

120.3 The Saving Mileage Model

120.3.1 The Main Idea

The basic idea of saving mileage method mainly from many paths to choose in the article, select a method of the best distribution path. The basic principle of this method is in the long triangle side geometry must be less than other sides combined. See Fig. 120.1.

The distribution center P deliver to two users A and B, the most short distance from P to A and B was separately for L_1 and L_2, the shortest distance between A and B for L_3. The user of A and B to cargo demand respectively for Q_1 and Q_2.

If use two cars to deliver the goods separately which are customers A and B needs, from their delivery, the car go straight total mileage as follows:

$$L = 2(L_1 + L_2) \tag{120.1}$$

If use a car to send the goods to A and B for tour delivery, set the Q_1 and Q_2 less than cars standard, the car walk overloaded weight mileage as follows:

$$L = L_1 + L_2 + L_3 \tag{120.2}$$

The later delivery plan less than a former delivery plan about the walk miles saving as follows:

$$\Delta L = 2(L_1 + L_2) - (L_1 + L_2 + L_3) = L_1 + L_2 - L_3 \tag{120.3}$$

If we look from the graphics, it is equal to the triangular two neighboring minus the sum of the poor.

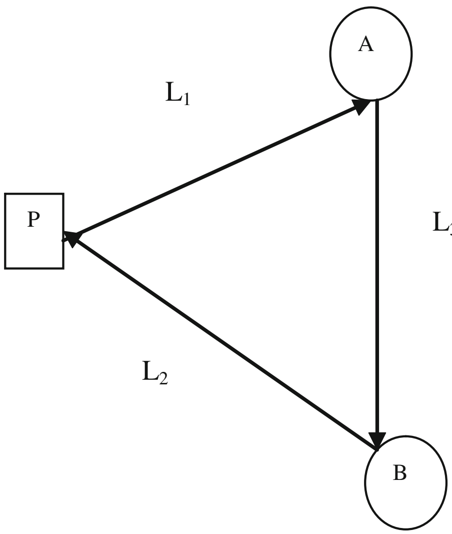

Fig. 120.1 Tour walking distance to shipping and delivery vehicles

120.3.2 Model Algorithm

If among the scope of distribution center P still exist within the 3, 4, 5, and… N users, with the permitting of the car load, it can rely on saving them to the quantity of tour route connected in turn, until the car carrying so far. The rest of the users use the same method to determine tour route and send another car.

Saving method route optimization through two distribution paths for a merger of one distribution path thought, reduce the total transportation distance. First figure out "saving the mileage" between any two points and arrange them from big to small, first merge the path of the big save mileage, in combining the load test vehicles and the total distance constraint. In the consolidated route, only in two different offline and direct to the distribution center connection points can merge, which means each point can merge two times at most, and in the same path of the two points can't merge. It needs to test these requirements in the merger.

The logistics cost structure of commercial union supermarket take up the large proportion of transportation costs, so we use save mileage model to optimize distribution path which can effectively reduce the total logistics costs.

120.4 Example Study

120.4.1 Establish the Model

According to the characteristics of commercial union supermarket, in order to improve the speed of distribution, decrease the logistics costs, this paper will take the merchants supermarket distribution path to save mileage. In order to facilitate analysis, now suppose between any two supermarkets that have an access, back and forth path length is the same. Distribution center has 123-ton vehicles and 45-ton vehicles.

The distribution of commercial union supermarket: A (P_1) Nanjing road store; B (P_2) Yangtze River west road store; C (P_3) Yangtze River store; D (P_4) Xiao Yin store; E (P_5) Yangtze River east road store; F (P_6) Beijing road store.

For commercial union supermarket, distribution center need to deliver goods to twelve stores, in order to facilitate the calculation, I will be respectively choose twelve stores in project for P_i ($i = 1, 2, 3 \ldots 6$), each of the store demand for R_i ($i = 1, 2, 3 \ldots 6$). We know some dates as in Table 120.1.

Table 120.1 List of distribution center traffic volume (ton)

P_i	P_1	P_2	P_3	P_4	P_5	P_6
R_i (t)	1.3	2.2	0.5	1.3	2.3	0.9

120.4.2 Calculation and Analysis of the Model

Initial distribution scheme of commercial union supermarket: this distribution plan needs 6 3-ton vehicles and total walk mileage is 75.374 km (Fig. 120.2).

According to VRP model, we can calculate commercial union supermarket of the shortest path distribution.

(1) To identify the most short lists, see Table 120.2.

(2) Calculate the saving mileage, and draw the odometer of save "milestones" (Table 120.3).

To P_1 and P_2, d_{12} equals to $2\,(c_{01} + c_{02}) - (c_{01} + c_{02} + c_{12})$ is 5.1 km. Each of other commercial union supermarket about the save mileage can depend on this formula.

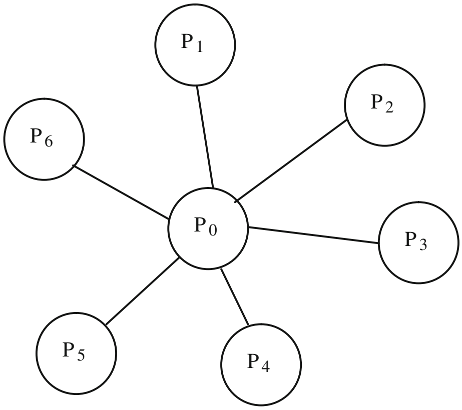

Fig. 120.2 Initial distribution network diagram

Table 120.2 Distance between the distribution center and a certain demand (kilometers)

Distance	P_1	P_2	P_3	P_4	P_5	P_6
P_0	18	2.5	1.8	0.287	2.5	2.6
P_1		15.5	16.3	18.0	15.5	15.7
P_2			0.884	2.5	0.014	1.2
P_3				1.7	0.898	0.904
P_4					2.5	2.4
P_5						1.2
P_6						

Table 120.3 The odometer of save "milestones" (kilometers)

d_{ij}	P_2	P_3	P_4	P_5	P_6
P_1	5.1	3.6	0.387	5.1	5
P_2		3.416	0.287	4.986	3.9
P_3			0.387	3.402	3.496
P_4				0.287	0.487
P_5					3.9

Table 120.4 Save mileage sequence (kilometers)

Number	Path	Save mileage
1	P_1–P_2	5.1
2	P_1–P_5	5.1
3	P_1–P_6	5
4	P_2–P_5	4.986
5	P_5–P_6	3.9
6	P_2–P_6	3.9
7	P_1–P_3	3.6
8	P_3–P_6	3.496
9	P_2–P_3	3.416
10	P_3–P_6	3.402
11	P_4–P_6	0.487
12	P_3–P_4	0.387
13	P_1–P_4	0.387
14	P_2–P_4	0.287
15	P_4–P_6	0.287

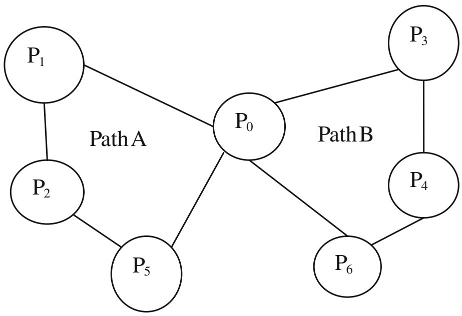

Fig. 120.3 Final distribution network

(3) According to save "milestones" how much mileages to be saved, range from large to small, work out the mileage form.

(4) According to save mileage sequence and vehicles carrying quantity to sure the merger route.

According to Table 120.4 the greatest saving mileage is P_1–P_2. So we first consider the supermarkets P_1 and P_2 to the same path earmarks. By freight volume, it is known that the volume of P_1 and P_2 sum for 3 t. And is also on the P_5 path, so P_0, P_1, P_2, P_5 formed A path. And follow it we get path B, Final distribution network as in Fig. 120.3.

From Fig. 120.3 we can get:

Path A: car in 5 t, distance is 36.014 km, and load is 4.8 t. Save mileage is 10 km.

Path B: car in 3 t, distance is 8.5 km, and load is 2.7 t. Save mileage is 1.874 km.

So walk a total mileage is 44.514 km; Save a total mileage is 11.87 km, need two drivers and two vehicles, respectively is 1 cars in 5 t and 1 car in 3 t. And the original distance is 75.374 km, need 6 drivers 6 cars in 3 t. So save 15.7 % of the mileage.

120.5 Conclusion

Through the analysis of logistics cost of commercial union supermarket, we find that if we want to reduce logistics distribution costs of commercial union supermarket, it is necessary to save time in distribution path. This paper analyzes the saving mileage model of optimization in commercial union supermarket on distribution path, and to a certain extent, it reduces the merchants supermarket of the transport distribution costs. The model in the optimization on distribution path is reasonable. We hope this research can have a certain benefit to promote the smooth development of commercial union supermarket.

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Chapter 121
Research on Multi-Stage Stochastic Location-Routing Problem of Logistics System Optimization

Shou-ying Li and Shi-wei Yun

Abstract Combining the characteristic of location-routing problem in logistics system optimization, the paper establishes an optimization model of multi-stage stochastic LRP with time windows, and introduces the matching improved genetic algorithm. The algorithm used seven-segment real-code and designed matching crossover and mutation operations, and catastrophe strategy was added in the iterative process to prevent "search slow" problem and accelerate convergence. The result of simulated test indicates that the model and the algorithm resolved the optimization LRP model in the logistics system effectively.

Keywords Improved genetic algorithm · Location-routing problem · Margins logistics system optimization

121.1 Introduction

The earliest research of location-routing problem started from the early 1980s. References (Min et al. 1998; Nagy and Salhi 2007) have reviewed the related previous research on the evolution, model classification and algorithm design. And they have explored the future directions of LRP. The LRP model integrated the LA (Location-Allocation Problem) problems and the VRP (Vehicle Routing-Problem) Problem. Compared with the previous optimization respectively, the LRP has a better effect by whole optimization. It has a wide range of applications in the

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logistics system optimization, such as the establishment of the distribution network, supply chain integration, etc.

The algorithm of LRP mainly includes exact algorithm (Stowers and Paleker 1993), heuristic algorithm (Wu et al. 2002; Zhang et al. 2004) and the intelligent algorithm. Because the LRP combines LA and VRP, they are all NP-Hard (Non deterministic Polynomial Hard) problem, in most cases, to solve the LRP by the exact algorithm is very difficult. The sketch of heuristic algorithm is divided the LRP into few sub-problems, and in turn applied accurate algorithm or heuristic algorithm to solve. The universal and portability of the heuristic algorithm is not so good. The changes of the model usually cause a radical change of the algorithm.

Intelligent algorithm includes simulated annealing algorithm (Yu et al. 2010), tabu search algorithm (Tuzun and Burke 1999; Albareda-Sambola et al. 2005), ant algorithm (Marco et al. 1996) and genetic algorithm (Zhang and Dang 2004), etc. The algorithm used tree shaped code and Evolutionary strategy. It is not the common solution of two stages. The advantage is solving the LRP as a whole and avoiding the solving process into local optimal.

In this paper, an optimization model of multi-stage stochastic location-routing problem (LRP) with time windows was established. The algorithm used real-code, genetic operator with self-adaptability and disaster strategy. The algorithm is efficient, convergent and stable, and the model is feasible.

121.2 Problem Description

In this paper, the problem of two-stage location-routing could be described as: the facilities class I (such as factories) distributes goods to facilities class II (such as distribution center) and the facilities class II distributes goods to customers.

Suppose that there are some customers, candidate secondary facilities II and I, different type vehicles. Different types of vehicles have different capacity limit, maximum distance and speed. Vehicles travel time obey normal distribution. Every vehicle only takes on a distribution task. Vehicles travel from facility they belong to from zero moment. And they return to the facilities they belong to when they complete the task.

121.3 Two-Stage Random LRP Model

$Q\{i|i = 1, 2, \ldots, n\}$ is the set of customer point; $P\{i|i = n+1,\ n+2, \ldots, n+m\}$ is the set of candidate facilities class II; $Gz_i(i \subset P)$ is the depreciation cost each day of the facilities class II i; $S\{i|i = n+m+1,\ n+m+2, \ldots, n+m+q\}$ is the set of candidate facilities class I; $Gz_i(i \subset S)$ is the depreciation cost each day of the facilities class I i; $W\{i|i = 1, 2, \ldots K\}$ is the set of vehicle belong to facilities class II; $W'\{i|i = 1, 2, \ldots, K'\}$ is the set of vehicle belong to facilities class I; R_i is the demand of customer i; $d_{ij}(i,j \in Q \cup P \cup S)$ is the distance of node and node j; C_k, L_k, V_k, D_k and G_k are the capacity of vehicle $k(k \in W \cup W')$, the maximum distance, speed, the cost each unit and the fixed costs of use a new vehicle; t_{ijk} is the random travel time of vehicle $k(k \in W)$ from $i(i \in Q \cup P)$ to $j(j \in Q \cup P)$, is considered to obey normal distribution; T_{ik} is the moment of vehicle $k(k \in W)$ get to $i(i \in Q)$; LT_{ik} is the moment at latest customer $i(i \in Q)$ requirements for vehicle $k(k \in W)$.

$x_{ijk} = 1$, if vehicle $k(k \in W \cup W')$ travel from node i to node j, $i \neq j$; if not, $x_{ijk} = 0$. $y_{ik} = 1$, if node i is distributed by vehicle $k(k \in W \cup W')$; if not, $y_{ik} = 0$. $z_i = 1$, if facilities class II i is used; if not, $z_i = 1$. $z_i^0 = 1$, if facilities class is used; if not $z_i^0 = 0$.

The model is as follows:

$$f(x) = \min\Big(\sum_{i\in S} z_i^0 G z_i^0 + \sum_{i\in P} z_i G z_i + \sum_{i\in P\cup Q}\sum_{k\in W\cup W'} y_{ik} G_k + \sum_{i\in Q\cup P}\sum_{j\in Q\cup P}\sum_{k\in W} x_{ijk} d_{ij} D_k + \sum_{i\in P\cup S}\sum_{j\in P\cup S}\sum_{k\in W'} y_{ijk} d_{ij} D_k\Big) \quad (121.1)$$

$$p\{T_{ik} \le LT_{ik}\} \ge \beta, \forall i \in Q, \forall k \in W \quad (121.2)$$

$$T_{ik} = T_{jk} + t_{jik}, \forall i,j \in Q \cup P, \forall k \in W \quad (121.3)$$

$$\sum_{k\in W\cup W'} y_{ik} = 1, \forall i \in P \cup Q \quad (121.4)$$

$$R_i' = \sum_{j\in Q}\sum_{k\in W}\left[x_{jik}\left(\sum_{j\in Q} y_{jk} R_j\right)\right], i \in P \quad (121.5)$$

$$\sum_{i\in Q} y_{ik} R_i \le C_k, \forall k \in W \quad (121.6)$$

$$\sum_{i\in P} x_{ik} R_i' \le C_k, k \in W' \quad (121.7)$$

$$\sum_{i\in S\cup P\cup Q}\sum_{j\in S\cup P\cup Q} x_{ijk} d_{ij} \le L_k, \forall k \in W \cup W' \quad (121.8)$$

$$\sum_{i\in S\cup P\cup Q} x_{ipk} - \sum_{j\in S\cup P\cup Q} x_{pjk} = 0,$$

$$\forall k \in W \cup W'; \forall p \in S \cup P \cup Q \quad (121.9)$$

$$\sum_{i\in P}\sum_{j\in Q} x_{ijk} \le 1, \forall k \in W \quad (121.10)$$

$$\sum_{i \in S} \sum_{j \in P} x_{ijk} \le 1, \forall k \in W' \quad (121.11)$$

$$\sum_{j \in P \cup Q} \sum_{k \in W \cup W'} x_{ijk} \ge z_i, \forall i \in S \cup P \quad (121.12)$$

$$\sum_{j \in P \cup Q} x_{ijk} \le z_i, \forall i \in S \cup P; \forall k \in W \cup W' \quad (121.13)$$

$$\sum_{j \in Q} x_{ijk} + \sum_{h \in Q} x_{hik} \le 1, \forall i \in P; \forall k \in W \quad (121.14)$$

$$\sum_{j \in P} y_{ijk} + \sum_{h \in P} y_{hik} \le 1, \forall i \in S; \forall k \in W' \quad (121.15)$$

In the above model, the objective function (121.1) aims at minimizing operating costs, including the day depreciation cost of the facilities, the fixed cost and operation cost of the vehicles. Constraint (121.2) ensure the probability meet the requirements of time window is not less than β when vehicles delivery to customer. Constraint (121.3) is the mathematical expressions of T_{ik}. Constraint (121.4) ensures that every customer and facilities class II is distributed by only one vehicle. Constraint (121.5) is the amount of goods facilities class II need to prepare. Constraint (121.6) and constraint (121.7) are the capacity constraint of vehicles. Constraint (121.8) is the maximum distance constraint of vehicles. Constraint (121.9) ensures that the travel route is continuous. Constraint (121.10) and constraint (121.11) ensure that a vehicle is only service for a facilities class II or a customer. Constraint (121.12) ensures there is a vehicle exit from each facilities class II and class I. Constraint (121.13) ensures there is no vehicle exit from facilities not chosen. Constraint (121.14) and constraint (121.15) ensure that any facilities class I or any two facilities class II will not be connected by vehicle.

121.4 The Improved Genetic Algorithm

121.4.1 The Code of Algorithm

Each chromosome has 7 substrings. Substring 1st has m genes (m is the number of candidate facilities II). Each gene chooses a natural number from 1 to K'at random as its value ($K'$is the number of vehicles belongs to facilities I). Substring 2nd has m genes. The genes value is a random natural permutation from 1 to m. Substring 3rd has K' genes. Each gene chooses a natural number from 1 to m at random as its value ($m$is the number of candidate facilities I). The construction of substring 4th, 5th and 6th are similar to the above three substrings. Substring 4th has n (n is the number of customers) genes. Each gene chooses a natural number from 1 to Kat random as its value ($K$is the number of vehicle belongs to facilities II). Substring 5th has n genes. Each gene chooses a natural number from 1 to n at random as its value Substring 6th has K genes. Each gene chooses a natural number from 1 to $m$at random as its value ($m$is the number of candidate facilities II). Substring 7th has 2 genes. One is the objective function value. The other is the fitness function value. The chromosome has a total of $m + m + K' + n + n + K + 2$ genes.

For instance, there are 10 customers, 3 candidate facilities II, 2 candidate facilities I, 2 vehicles belong to facilities I, 4 vehicles belong to facilities II. As the following chromosome (not include the substring 7th) indicate that the route of vehicle 1st and vehicle 2nd are 2–1–2 and 1–3-2—1. Two candidate facilities I all were enabled.

$$\underbrace{2-1-2-}_{\substack{\text{Substring}\\ \text{1st}}}\underbrace{3-1-2-}_{\substack{\text{Substring}\\ \text{2nd}}}\underbrace{2-1-}_{\substack{\text{Substring}\\ \text{3rd}}}\underbrace{1-4-4-1-2-4-2-2-4-1-}_{\text{Substring 4th}}$$

$$\underbrace{3-9-6-4-5-1-8-2-7-10-}_{\text{Substring 5th}}\underbrace{3-1-2-3}_{\text{Substring 6th}}$$

121.4.2 The Solution of Stochastic Constraint

t_{ijk} is the random time vehicle $k(k \in W)$ travel from node $i(i \in Q \cup P)$ to node $j(j \in Q \cup P)$. If t_{ijk} is supposed obey known normal distribution. For the normal distribution properties, the moment of vehicle $k(k \in W)$ reach node $(i \in Q)$ T_{ik}obey normal distribution too. And the expected value is the expected values sum of t_{ijk} each section from facilities to node i. The variance is the variances sum of each section. For the expected value and variance of t_{ijk}, their value based on the distance between node i and node j, and the speed of vehicle k. The expected value is d_{ij}/V_k.The variance is $(d_{ij}/V_k)c$. c is a real number between 0 and 1. For the chromosomes do not meet the constraints (121.2), the paper add a penalty function to objective function value using the function of norm cdf in MATLAB, and reflect the degree of don't meet. So as to reduce the individual fitness reasonably, reduce its ability to reproduce and the chance to be chose. The penalty function is $(\beta - p\{T_{ik} \le LT_{ik}\}) * M$, M is a large constant.

121.4.3 Initial Population and Fitness Function

The population has *num* chromosome. The produce method is as follows: generate a chromosome randomly, then judge whether it meet the capacity constrain and the distance constrain, if meet, it is retained, or generate a new chromosome, until generate *num* chromosome.

Fitness function is $f_i = Z_{\min}/Z_i . f_i$ is the fitness function value of chromosomes i. $Z_{\min}$ is the minimum fitness function value in the same generation. Z_i is the objective function value of chromosomes i. Therefore, the range of the fitness function value is $(0,\ 1]$.

121.4.4 Crossover, Mutation and Selection Operation

To prevent generate error codes, different chromosomes choose different crossover and mutation operators. Substring 1, 3, 4, 6 choose two-point crossover and shuffle crossover. Substring 2, 5 choose order crossover and partial matching crossover. Substring 1, 3, 4, 6 choose uniform mutation. Substring 2, 5 choose reverse mutation.

The selection operation chooses the dynamic elite reserves and roulette. Before generate next generation of population, the temporary population generated by crossover and mutation operation should be ordered based on fitness. The chromosomes at the front will be copied into the next generation of population. The other chromosomes of the new population will be chose from father generation and temporary population by roulette selection operation.

The dynamic elite reserves selection operation refers to the number of the reserved chromosomes will decreases with the iteration increase. So in the early evolution the excellent individual's ability to reproduce can be ensured to speed up the convergence. In later the population won't be monopolized by few more optimal individual and increase the diversity of population.

121.5 Conclusion

An example has been validated the model and algorithm. It includes 20 customer points, 8 candidate facilities class II, 4 candidate facilities class I, 4 vehicles belong to facilities class I, 8 vehicles belong to facilities class II. Here no elaboration on it. Analysis result shows that the algorithm is efficient, convergent and stable, and the model is feasible.

This paper established a minimal cost single objective LRP model. In fact, the time efficiency maximization is the objective of logistics system too. So the multi-objective LRP needs further research. In addition, the randomness and the fuzziness of customer demand is a focus in the future research.

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Chapter 122
Research on Purchase and Sale Equilibrium of Supermarkets' Vegetables Based on Marginal Analysis

Yuan-yuan Yu and Li-wei Bao

Abstract The policy of "Supermarket-Farmer Direct Purchase" has been promoted for many years. As daily necessities in ordinary families, vegetables are key objects of "Supermarket-Farmer Direct Purchase". Once consumers enter the supermarkets, they wouldn't choose other channels to purchase vegetables, so that supermarkets seem to be a monopolist. In general, supermarkets run various vegetables, each of which is affected by prices of other vegetables. This paper analyzes the purchase and sale equilibrium of vegetables in supermarkets with the principle of profit maximization and marginal analysis, combined with mutual influences among vegetables. This contributes to make a right decision for supermarkets, reduce stuttering in agricultural products supply chain, break through traditional demand forecast and popularize "Supermarket-Farmer Direct Purchase".

Keywords Marginal analysis · Purchase and sale equilibrium · Supermarkets · Supply chain · Vegetables

122.1 Introduction

Ministry of Commerce and Ministry of Agriculture issue a document to deploy the pilot work of "Supermarket-Farmer Direct Purchase" at the end of 2008 (Zhang and Li 2010). The literal meaning of "Farmer-Supermarket Direct Purchase" is that the agricultural producers (farmers) sell agricultural products to the

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supermarkets directly or the supermarkets purchase agri-products from the producers without intermediaries (Hu 2010). In the model of “Supermarket-Farmer Direct Purchase”, supermarkets become sales ends and core organizations in fresh agricultural products supply chain (Li 2011) and vegetables are key objects of “Supermarket-Farmer Direct Purchase”. The amount of vegetables consumption occupies a large proportion of total consumption and vegetables have almost become basic necessities. Since the introduction of reform and opening, sales channels of fresh agricultural products have been the objects of studies in marketing economy (Tang 2011; Zhao and Yang 2009; Wang and Yu 2012; Wang et al. 2011). Agricultural trade market is a major player in sales channels of fresh agricultural products but with the development of social economy and improvement of living standards people put forward higher requirements for purchase places (Yuan 2008). More supermarkets begin to answer the call of “Supermarket-Farmer Direct Purchase” to conduct the business of fresh agricultural products such as fruits and vegetables so that consumers have more choices in buying vegetables. Agricultural trade markets are dominated by individual peddlers and vendors, in which business scope is flexible and mobile, market reaction is fast and cost per unit is low (Zhang 2006). However, supermarkets are more competitive in the aspect of shopping environment, food safety, quality of service, reputation and so forth (Mao 2010; Ding 2008). Agricultural trade markets provide a place where buying and selling take place and there are many peddlers and vendors dealing with consumers. Agricultural trade markets can be regarded as perfectly competitive markets. While in the supermarket, they wouldn’t choose other channels to purchase once entering, so that supermarkets seems to be exclusive monopoly markets. This paper carries out purchase and sale equilibrium research based on this premise.

As a rational person, supermarkets pursue profit maximization, so determining purchase volume becomes a crucial aspect to make a profit. Traditionally, supermarkets predict demand according to historical sales data but this method is not so scientific for not considering mutual influences among vegetables. That is, the sales of certain kind of vegetable are affected by the prices of other vegetables. The perspective this paper takes overcomes the deficiency to some extent. The research will help the supermarkets to rationalize the operational mechanism of fresh agricultural products represented by vegetables, overcome obstacles of agricultural products supply chain, perfect traditional demand forecast and popularize “Supermarket-Farmer Direct Purchase”.

122.2 Assumptions

In this section, we make some assumptions to let our research more convincing.

Firstly, supermarkets are rational persons who pursue profit maximization which conforms to assumptions in economics. Secondly, after a tradeoff between supermarkets and agricultural trade markets, consumers choose to purchase in supermarkets. What's more, they wouldn't choose other channels so that supermarkets can be regarded as a monopolist. Thirdly, supermarkets can purchase unlimited quantities of vegetables, which means we can ignore shortage of vegetables. Fourthly, supermarkets offer n kinds of vegetables for sale and the sales of certain kind of vegetable is affected by the prices of other vegetables. There exists some alternative among vegetables. In reality, consumers are willing to buy different vegetables to take more nourishment. Lastly, vegetables are likely to perish, or spoil. The wastage of rotten vegetables will be classified as costs.

122.3 Basic Conceptions

Before formal analysis, let us introduce some basic conceptions and symbols we use.

122.3.1 Profit Maximization

As a rational person, supermarket regards profit maximization as its target (Dong and Zhou 2009). The profit here is economic profit or super profit which is the gap between total revenue and total cost (Varian 2011). In economic analysis, maximizing profit suggests marginal revenue equals marginal cost which means the revenue is the same as cost brought by last unit product (Dong and Zhou 2009). This principle could not only apply to perfect competition but also to monopolistic competition (Wu 2001). As we have assumed, supermarket is a monopolistic. We write TR to express total revenue of supermarket, TC total cost and π profit, so we get $\pi = \mathrm{TR} - \mathrm{TC}$.

122.3.2 Demand Mapping

We have supposed there are n kinds of vegetables. If P is price vector $(P1,\ P2, \ldots, Pn)$, Q is demand vector $(Q1,\ Q2, \ldots, Qn)$, then demand mapping of n vegetables is $Q = D(P) = (D(P),\ D2(P), \ldots, D(P))$. The ith vegetable's demand function is defined as $Qi = Di(P) = Di(P1,\ P2, \ldots,\ Pn)$ with $i = 1, 2, \ldots, n$.

122.3.3 Cost Function

When selling vegetables, some costs can be incurred such as input costs, logistics costs, labor costs, transaction costs and so on. In general, supermarket adopts various purchase channels for different vegetables, thus incurring different costs.

We shall use $Ci = Ci(Qi)$ to denote the cost function of ith vegetable. Then the total cost function can be written as $TC = C(Q) = \sum_{i=1}^{n} Ci(Qi)$. Compared with industrial products, vegetables have shorter shelf life. Once out of this valid period, vegetables will rot and lose sales value. So we have to take wastage of vegetables into account when purchasing (Chen 2009). Then supermarket may predict deterioration rate in light of historical data. We can write αi to represent the deterioration rate of ith vegetable and Qi to demand, so $Qi/(1-\alpha i)$, $Qi\alpha i/(1-\alpha i)$, $PiQi\alpha i/(1-\alpha i)$ are purchase volume, wastage volume and wastage costs respectively.

122.3.4 Jacobian Matrix

In this section, we'll give the definition of Jacobian matrix. We suppose $F: Rn \to Rm$ is a function from n-dimensional Euclid Space to m-dimensional Euclid Space. This function is made up of m real functions: $y1(x1, \ldots, xn), \ldots, ym(x1, \ldots, xn)$. If there exist partial derivatives of all these functions, then we get $m \times n$ Jacobian matrix:

$$\begin{bmatrix} \frac{\partial y1}{\partial x1} & \cdots & \frac{\partial y1}{\partial xn} \\ \vdots & \ddots & \vdots \\ \frac{\partial ym}{\partial x1} & \cdots & \frac{\partial ym}{\partial xn} \end{bmatrix}$$

This matrix can also be written: $J(x1, \ldots, xn)$ or $\frac{\partial(y1, \ldots, ym)}{\partial(x1, \ldots, xn)}$..

In our paper, demand mapping of n vegetables is $Q = D(P) = (D(P), D2(P), \ldots, D(P))$ and the ith vegetable's demand function is defined as $Qi = Di(P) = Di(P1, P2, \ldots, Pn)$. So the Jacobian matrix in this paper can be defined as:

$$J(P) = \frac{\partial(Q1, Q2, \ldots, Qn)}{\partial(P1, P2, \ldots, Pn)} = \begin{bmatrix} \frac{\partial Q1}{\partial P1} & \cdots & \frac{\partial Q1}{\partial Pn} \\ \cdots & \ddots & \cdots \\ \frac{\partial Qn}{\partial P1} & \cdots & \frac{\partial Qn}{\partial Pn} \end{bmatrix}$$

And corresponding Jacobian determinant can be expressed as:

$$\begin{vmatrix} \frac{\partial Q1}{\partial P1} & \cdots & \frac{\partial Q1}{\partial Pn} \\ \cdots & \ddots & \cdots \\ \frac{\partial Qn}{\partial P1} & \cdots & \frac{\partial Qn}{\partial Pn} \end{vmatrix}$$

We write $\partial Qi/\partial Pj$ to represent the variation of ith vegetable when the price of jth vegetable changes one unit. We shall use row i $(\partial Qi/\partial P1, \partial Qi/\partial P2, \ldots, \partial Qi/\partial Pn)$ to express demand variation of ith vegetable when the price of all vegetables change one unit (http://zh.wikipedia.org/wiki/%E9%9B%85%E5%8F%AF%E6%AF%94%E7%9F%A9%E9%98%B5).

122.4 Analysis

We shall analyze this question based on hypothesis conditions above.

As long as to any price vector P(P1, P2, ..., Pn) Jacobian matrix defined above is not equivalent to zero, there exists inverse mapping $P = D^{-1}(Q) = \varphi(Q)$ for demand mapping $Q = D(P)$. We suppose Jacobian matrix is not zero everywhere, so $P = D^{-1}(Q) = \varphi(Q)$ exists. Price vector $P = \varphi(Q)$ can be written $(P1, P2, \ldots, Pn) = (\varphi 1(Q), \varphi 2(Q), \ldots, \varphi n(Q))$, and $Pi = \varphi i(Q)$ is also said to inverse demand function for ith vegetable where i = 1, 2, … ,n. The total revenue function of ith vegetable is $TRi = \varphi i(Q)Qi$, and total revenue is $TR = \sum_{i=1}^{n} \varphi(Q)Qi = \varphi(Q)Q$ where $\varphi(Q)Q$ is vector inner product. We have known that the cost function of ith vegetable is $Ci = Ci(Qi)$, so the total cost function is $TC = C(Q) = \sum_{i=1}^{n} Ci(Qi)$ and profit function is $\pi = TR - TC = \varphi(Q)Q - C(Q) = \sum_{i=1}^{n} (\varphi i(Q)Qi - Ci(Qi))$.

A determination of reasonable demand Q is a must if supermarkets intend to maximize its profit. So the condition $\pi' = 0$ has to be satisfied. That is, $\frac{\partial \pi}{\partial Qi} = \sum_{i=1}^{n} \frac{\partial TRi}{\partial Qj} - Cj'(Qj) = \varphi j(Q) - Cj'(Qj) + \sum_{i=1}^{n} Qi \frac{\partial \varphi i(Q)}{\partial Qj} = 0.$

The condition for supermarkets realizing profit maximization is $\sum_{i=1}^{n} \frac{\partial TRi}{\partial Qj} = Cj'(Qj)$ where $j = 1, 2, \ldots,$ n which is identical to the theory in economics we have referred to that marginal revenue equals marginal cost. This condition can be interpreted as marginal cost of every kind of vegetable is equal to the sum of all kinds of marginal revenue of this kind vegetable.

The condition of profit maximization can also be expressed as $\varphi j(Q) + \sum_{i=1}^{n} Qi \frac{\partial \varphi i(Q)}{\partial Qj} = Cj'(Qj)$. When the amount of jth vegetable increase one unit, the price variation of ith vegetable is $\partial \varphi i(Q)/\partial Qj$ where $i = 1, 2, \ldots,$ n, then the total variation of revenue for i vegetables is $\sum_{i=1}^{n} Qi \frac{\partial \varphi i(Q)}{\partial Qj}$. The extra revenue brought by jth vegetable is $Pj = \varphi j(Q)$, so the total revenue variation for supermarkets is $\varphi j(Q) + \sum_{i=1}^{n} Qi \frac{\partial \varphi i(Q)}{\partial Qj}$. Besides, the variation cost caused by one unit jth vegetable is marginal cost Cj'(Qj). If increased total revenue is more than increased total cost, then increasing j will rise the profit, and vice versa. Only when the gap between increased total revenue and total cost is zero, the supermarkets get the maximum profit.

In the end, when the demand Qi is determined, we can obtain purchase volume on the basis of deterioration rate αi. In addition, if the rising sales of j will cause rising price of i, that is $\partial \varphi i(Q)/\partial Qj > 0$, then i and j are alternatives. And if the rising sales of j will cause falling price of i, that is $\partial\varphi i(Q)/\partial Qj < 0$, then i and j are complements.

122.5 Conclusion

It has been a trend that supermarkets run the business of agricultural products such as fruits and vegetables. Against thus background, our research applies profit maximization and marginal analysis in economics to the situation in which consumers buy vegetables in supermarket not agricultural trade market. This paper provides certain reference basis for supermarkets running strategy, overcomes obstacles of agricultural products supply chain, and popularizes "Supermarket-Farmer Direct Purchase". In practice, supermarkets can predict demand of every kind of vegetables according to historical sales data. However, this forecast is not so scientific lacking consideration of mutual influences among vegetables. Our research improves the accuracy of the prediction. Nevertheless, there are some points in this paper where there is not satisfactory. This will prompt more researchers to conduct studies.

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Chapter 123
Research on Reliability Allocation and Optimization of Logistics Supply Chain

Ya-qun Gao

Abstract Based on the concept of the cost function of reliability engineering, the paper built a cost function for estimation of the logistics supply chain reliability. A logistics supply chain reliability allocation model is set up combining with the structural characteristics of the supply chain. Depended on differential properties of the logistics supply chain and reliability cost, an iterative algorithm is constructed, in which maximized importance degree unit is used as searching unit.

Keywords Logistics supply chain · Reliability · Optimization · Cost function

123.1 Introduction

Reliability is a fundamental property of the supply chain, supply chain operations based on reliability is accompanied by uncertainty common objective phenomenon (Marting 1998). Logistics supply chain is a complex process, it has to participate in the main, cross-regional and multi-link characteristics of the logistics supply chain more susceptible to influence from the external environment and the chain of entities internal uncertainties, resulting in the supply chain a variety of issues. Because of these uncertainties, reliability has become the key elements that can ensure the normal operation of the supply chain (Cox 1997).

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123.2 Reliability Estimate Cost Function of Logistics Supply Chain

The distribution of system reliability in the system design, overall system reliability indicators are assigned to the various subsystems, components and components of the system reliability requirements for the system or product manufacturing process to ensure that the system or product to achieve the total reliability index (Stevens 1989). System reliability allocation problem has become an important issue in the system or product reliability design, the decile distribution method, the score distribution method, the failure rate weighted distribution method, importance and complexity of the distribution method, LaGrange distribution method allocation criteria can no longer meet the requirements of the precise distribution of the complex system (Lin and Lin 2006). Many scholars have put forth a lot of new reliability allocation method (Donnell et al. 2006).

For many reliability allocation method, the technology is relatively mature, but the object of these studies are a practical system (Duc et al. 2008), such as product supply chain system, few studies of its reliability allocation problem is difficult in practice, most been applied (Ouyang 2007). In view of this, this article combined with supply chain structure reliability analysis of the feature from the reliability cost function and reliability on the relationship between the changes, and puts forward a new and simple algorithm, are more likely to used in the reliability distribution logistics supply chain, guarantee the successful operation of logistics supply chain.

(1) *Cost function of reliability estimate*: In reliability engineering, the cost as a reliability function model is a challenge (Wangphanich et al. 2007), based on actual cost data by fitting the cost function is very difficult. In many cases, the quantization parameter is not easy.

The existing reliability cost functions include exponent model, polynomial model, the LaGrange model, the logarithmic model and the exponential model (Suman 2003; Liang and Smith 2004). The biggest flaw of these models is to have a constant need to determine these constants with the system, subsystem reliability are not closely related. In addition, more data needed to determine these constants, but for each system, statistic of subsystem running costs and reliability is very difficult, thus limiting the use of these models (Tian et al. 2009). In 1986, scholar Dale raised the cost function must satisfy some properties, to overcome this problem.

Assuming any subsystem i has a reliability R_i, exists $0 \le R_i(1) \le R_i(2) \le 1$, $c(R_i(1), R_i(2))$ represent the cost it will spent when the subsystem reliability R_i, increased from $R_i(1)$ to $R_i(2)$, then:

① $c(R_i(1), R_i(2)) \ge 0, \quad 0 \le R_i(1) \le R_i(2) \le 1$;

② $c(R_i(1), R_i(3)) = c(R_i(1), R_i(2)) + c(R_i(2), R_i(3)), 0 \le R_i(1) \le R_i(2) \le R_i(3) \le 1$;

③ $c(R_i)$differentiable;

④ $\frac{\partial^2}{\partial^2 p} c(R_i) \geq 0, \quad 0 \leq R_i \leq 1;$

⑤ For any fixed R_i, $0 \leq R_i \leq 1$, if $R_i(2)$ is approaching to 1, $c(R_i(1), R_i(2))$ is approaching to ∞;

⑥ $c(R_i)$ is monotone increasing function

(2) *Logistics supply chain reliability estimate cost function*: In this paper, logistics supply chain system is divided into a supplier subsystems, manufacturer's subsystems and distributors' subsystems (Liu et al. 2007). The failures of each subsystem are caused by multiple bottom events (Ramirez-Marquez and Rocco 2008). To establish the functional relationship between the cost and reliability of the bottom events, we can refer to the approach of the functional relationship between the machine parts reliability and its cost.

According to the relationship between the cost and reliability of the bottom events, a more practical cost function, which is called Cost function of reliability estimate, is established which can be used in the reliability distribution of logistic supply chain. The function is as follow:

$$C_i(R_i, f_i, W_i, R_{i,\min}, R_{i,\max}) = e^{\frac{1-f_i}{W_i} \bullet \frac{R_i - R_{i,\min}}{R_{i,\max} - R_i}} \tag{123.1}$$

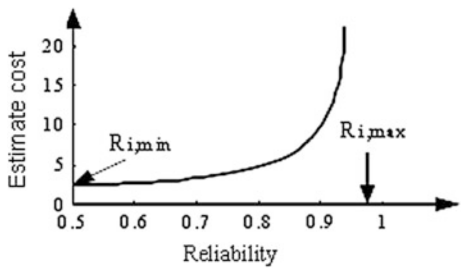
This is an exponential function model consists of four parameters: f_i, W_i, $R_{i,\min}$, $R_{i,\max}$. R_i indicates the reliability of the i th bottom event should be allocated; f_i is the feasible degree to improve reliability of the i th bottom event; W_i is impact factor of the i th bottom event; $R_{i,\min}$ is the reliability of the i th bottom event; $R_{i,\max}$ is the maximum reliability that the i th bottom event can reach with the existing conditions, Thus, formula (123.1) should be expressed as:

$$C_i(R_i) = e^{\frac{1-f_i}{W_i} \bullet \frac{R_i - R_{i,\min}}{R_{i,\max} - R_i}} \tag{123.2}$$

C_i indicates the cost of the i th bottom event, its basic graphics as shown in Fig. 123.1.

The figure shows that cost function of reliability estimate has the following characteristics: The cost function of reliability estimate is a non-linear growth function; the cost of bottom events has increased with the growth of reliability; if the bottom event achieve maximum reliability, then the theoretical cost will be infinite; the more the reliability improved, the greater the cost increased, the more

Fig. 123.1 Reliability estimate cost function digraph



difficult it is to implement. Therefore, the cost function of reliability estimate meets the basic requirements of the actual cost function.

(3) *Parameter determination*:

① Determination of the feasible degree f_i: In the logistics supply chain system, feasible degree f_i indicates the difficulty of the reliability of the i the bottom event. f_i is a relative value. Limited by the complexity of each bottom event, degree of difficulty as well as technical factors, it is harder to improve reliability of some bottom event than the others (Viladimirsky 2000). The more difficult it is to improve reliability, the higher cost it will be (Hughes 1987). Feasible degree value ranges in [0, 1]. The greater the value is, the easier it is to improve reliability of the bottom event, and reliability estimate cost is lower then. Curve of reliability estimate cost changing according to f_i is shown in Fig. 123.2. The curve is gentle if the feasible degree is big; reliability estimate cost transform is relatively slow. Conversely, the transform is faster.

② Determination of the impact factor W_i: In the logistics supply chain, the impact factor W_i represents the reliability influence degree of the entire supply chain system when i the bottom event is failure. Because of each bottom event in the whole supply chain system in different locations, the complexity of their systems and the role its impact on the entire supply chain system is not the same, the requirements of reliability is not the same. The greater the value of W_i, the more necessary to improve the reliability of this bottom event, curve of reliability estimate cost changed according to W_i is shown in Fig. 123.3. A method to determine the impact factor: Calculate the importance degree of each bottom event, choose the most important bottom event and let its impact fact equal to 1. Impact factor value ranges in [0, 1].

③ Determination of the maximum reliability $R_{i,\max}$: $R_{i,\max}$ represents the limit reliability that each bottom event can reach under the existing conditions. Because of certain constraints, the reliability of each bottom event can not reach the ideal 1. Therefore, the reliability of each bottom values in [$R_{i,\min}$, $R_{i,\max}$]. Curve of Reliability estimate cost changing according to $R_{i,\max}$ is shown in Fig. 123.4. The curve is gentle if $R_{i,\max}$ is big, reliability estimate cost transform is relatively slow. Conversely, the transform is faster.

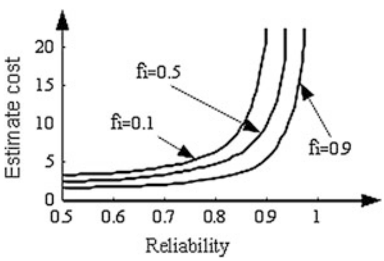


Fig. 123.2 Curve of reliability estimate cost changing according to f_i

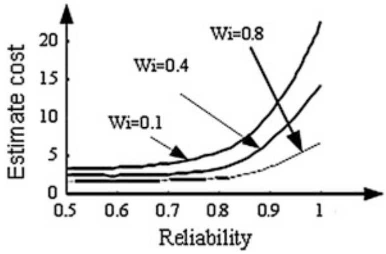


Fig. 123.3 Curve of reliability estimate cost changed according to W_i

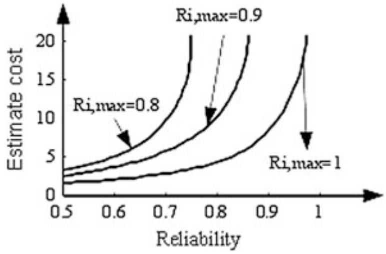


Fig. 123.4 Curve of reliability estimate cost changing according to $R_{i,\max}$

123.3 Reliability Allocation Model of Logistics Supply Chain

The goals of logistics supply chain reliability allocation model are to minimum the total operating cost and to meet the system reliability requirements. Therefore, a nonlinear programming model can be built as follow:

$$\text{Objective function} : C = \sum_{i=1}^{n} C_i(R_i) \tag{123.3}$$

Constraint conditions:

$$\begin{cases} R_S = f(R_1, R_2, \cdots, R_{u+6n}) \geq R_G \\ R_{i,\min} < R_i < R_{i,\max}, i = 1, 2, \cdots, u + 6n \end{cases} \tag{123.4}$$

Among them, C represents cost of reliability estimate; R_S represents system reliability; R_G represents desired value of system reliability.

123.4 Algorithm

In the reliability allocation model of logistics supply chain, the objective function and constraint functions are both the increasing function of the reliability of the bottom event. Thus, increased reliability of the bottom event will increase the total cost of the system, of course, the system reliability will be improved, but how to achieve the maximum system reliability with the minimum costs is the target of this algorithm. Therefore, this paper defines an important degree $P_i(i = 1, 2, \cdots, u + 6n)$ of reliability and cost of the bottom event as

$$P_i = \frac{\partial f}{\partial C_i} = \frac{\partial f}{\partial R_i} \Big/ \frac{\partial C_i}{\partial R_i} = \frac{I_f(i)}{I_C(i)} \tag{123.5}$$

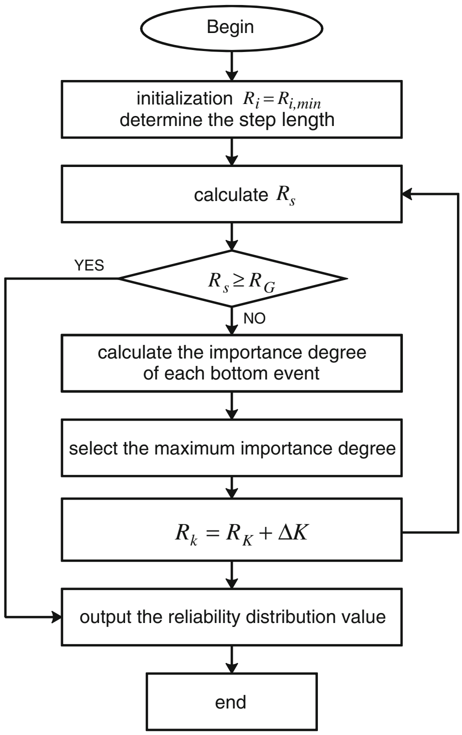
Among them, $I_f(i) = \frac{\partial f}{\partial R_i}$ represents important degree of structural reliability probability, $I_C(i) = \frac{\partial C_i}{\partial R_i}$ represents cost function derivation of reliability.

This importance degree P_i means that the increase in unit costs caused the increase of system reliability. It shows the impact that cost changes has influence on the reliability of the entire logistics supply chain system. Thus, when a bottom event is getting more and more important, it means this bottom event has a greatest impact on the system reliability. So, this paper selects the optimal unit by comparing the importance degree of each bottom event, and through the iteration step length to promote algorithm, until the reliability of the system requirements is meet, so the distribution of the reliability is the most economic.

Specific algorithm:

① initialize each variable and determine the search step length ΔR. $R_i = \min\{R_1, R_2, \cdots, R_{u+6n}\}$, the step length can be determined according to the system reliability requirements. In general, the step length can be identified as 0.001;

Fig. 123.5 Reliability allocation algorithm of logistics supply chain



② Calculate the system reliability $R_S = f(R_1, R_2, \ldots, R_k, \ldots, R_{u+6n})$, judgment whether R_S is equal to a predetermined reliability R_G. If R_S less than R_G, that means the result does not meet the system reliability requirements, then turn to step ③; If $R_S \geq R_G$, record the reliability value of each bottom event, the program is end.

③ Calculate the importance degree of each bottom event $P_i(i = 1, 2, \cdots, u + 6n)$, and compares them, $P_k(k \in i) = \max\{P_1, P_2, \cdots, P_{u+6n}\}$, $R_k = R_k + \Delta R$.

The program flowchart of the algorithm is shown in Fig. 123.5.

123.5 Conclusion

This paper uses for reference the machine parts reliability distribution method, on the basis of reliability engineering of the law of the cost function and reliability, constructs the logistics supply chain reliability, estimates the cost function, and establishes reliability distribution model of the logistics supply chain. According to the logistics supply chain reliability and cost differential properties, this paper constructs an important degree with maximum unit for search unit gradually iterative algorithm. Compared with the algorithm of the existing literature, this algorithm is simple and easy to use. It can solve the problem of the reliability distribution of the logistics supply chain.

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Chapter 124
Research on the Application of Mobile Agent in Supply Chain Management System

Jie Xiao, Chun-dong Wan and Jian-dong Zhang

Abstract The introduction of mobile agent to supply chain will strengthen information transmission speed and sharing degree of each links of supply chain network, and then enhance the agility of supply chain and the quick response ability, reduce the bullwhip effect. The supply chain management system model based on mobile agent is presented and several key issues of system realization are discussed.

Keywords Mobile agent · Supply chain · Supply chain management system · System model

124.1 Introduction

With the improvement of science and technology and the development of economy, global manufacturing and economic integration, the competition among enterprises has become the competition among supply chains. Technological progress and demand diversification have made the product life cycles shorten and the enterprises are facing the challenge of shorter delivery time, product quality improvement, cost reduction and service improvement. Enterprises not only need to consider the coordination of internal resources, but also from the point of entire supply chain to research coordination among enterprises in order to enhance the rapid response ability of supply chain. The trend of market globalization and the fierce market competition, advanced manufacture technology, rapidly developed IT technology, and modernization of the circulation field's management mode bring new opportunities and challenges to supply chain management.

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Because of the inherent uncertainty and dynamic characteristics, how to design an effective supply chain management model is still very difficult. According to the dynamic feature of supply chain management mode, a model of supply chain management system based on mobile agent is presented. It is significant for further research of enterprise supply chain management system and enhancement of enterprise competition.

124.2 Supply Chain Management System Model Based on Mobile Agent

124.2.1 Mobile Agent Technology

In early 1990, the concept of mobile agent was put forward when General Magic Company proposed the commercial system Telescript. Simply speaking, mobile agent is a program which can independently migrate from one host to another one in heterogeneous network, and can interact with other agent or resources. In fact it is the combination of agent technology and distributed technology (Wooldridge and Jennings 1995).

Mobile agent is a kind of special agent. Besides the basic characteristics of agent, the mobility is the most important characteristic of it. Mobile agent's characteristics can be represented by alleviating network load, overcoming network delay, asynchronous independent execution, offline calculation, platform irrelevancy, dynamic adaptability, fault-tolerance ability and so on. Just because the above characteristics which agent has, it is widely applied in many fields such as electronic commerce, individual assistant, security proxy, distributed information retrieval, telecommunication network service, invasion inspection system based on mobile agent, GIS system, mobile database system as well as solving some mathematics questions with mobile agent technology (Zhang 2002), etc.

124.2.2 Research Status of Supply Chain Management at Home and Abroad

Currently, supply chain management research focuses on two aspects: one is theoretical research on the model, concept and scope of supply chain management, and the other is application research on the concrete realization technology of supply chain management.

Supply chain modeling is the basis of constructing reasonable supply chain, and also helps the development of supply chain management system, therefore becomes the research focus at present. In other countries, with the widespread implementation of supply chain management, there are many theories and models based on supply chain management, such as coordinated supply chain management structure put forward by Tomas (Tomas and Griffin 1996), models for multi-plant coordination established by (Bhatnagar and Chandra 1993), and the three levels of supply chain management structure designed by (Fox et al. 1992), etc.

In addition, the supply chain entity is very consistent with the concept of multi-agent in distributed artificial intelligence. Therefore, introducing multi-agent theory to supply chain management is also a research focus. Although the multi-agent technology has not yet entered the practical stage, current research has shown its great potential.

In China, due to the relatively late introduction of supply chain management, the real supply chain management research has yet just started in recent years, but growing fast.

Domestic universities and research institutes have launched a wave of supply chain research, made significant progress and breakthroughs in theoretical research and technology implementation, and achieved encouraging results. In the supply chain design, the scholars have proposed product-based supply chain design, multi-agent based supply chain design, web-based supply chain design and e-commerce based supply chain design, etc. Combined with agile manufacturing theory, domestic scholars have proposed agile supply chain management, and combined with coordinated control theory, proposed coordinated supply chain management and etc (Qiao 2006; Lou et al. 2005; Lei et al. 2001).

124.2.3 Introduction of Mobile Agent to Supply Chain Management System

Supported by computer and network technology, the agile and knowledgeable characteristics of supply chain become more significantly. With the continuous development of artificial intelligence technology and the application in supply chain, it provides an effective method to solve the lack of coordination of supply chain system and reduce the bullwhip effect by using the agent's initiative, interaction, responsiveness, autonomy and etc.

At present, the research is very extensive by using agent technology to solve the problem of production control and management at home and abroad. Swaminathan have constructed the framework of supply chain simulation using multi-agent; integration laboratory of university of Toronto has established multi-agent development tool with LISP language, using it for a comprehensive study of supply chain management; Fox have constructed a supply chain management system including order agent, logistics agent, transport agent, plan agent, resource agent and distribution agent; According to the uncertainty and dynamic characteristics of supply chain, Xiao-hong Li have constructed the dynamic supply chain system based on mobile agent. According to the mobile agent's specific tasks at different stage of project life cycle, mobile agent is divided into four categories, information collection and release agent, negotiation agent, life process control agent and service maintenance agent (Ren et al. 2006; Xue et al. 2005; Wu and Wang 2004). The introduction of mobile agent provides a new way for supply chain management and enterprise information system integration.

124.2.4 Supply Chain Management System Model Design Based on Mobile Agent

When establishing a supply chain management system based on mobile agent, first of all, an important issue is how to divide the whole supply chain into several agents of different functions, called the agent function mapping. Each agent has a certain function, and can collaborate with other agents to solve problems (Liu and Li 2007). In multi-agent supply chain, the introduction of mobile agent can link the distributed agents and make each node of distributed supply chain intelligent and dynamic, and has the ability to solve large scale problems. Using mobile agent technology can achieve information sharing among the supply chain nodes, and then resolve problems of supply chain optimization, collaboration, coordination, and etc.

Through Internet or Intranet, mobile agent moves among suppliers, manufacturers, distributors and retailers to realize coordination management between enterprises on supply chain, as shown in Fig. 124.1.

Since the activities of each node in supply chain are carried out around the order, so in the design of this model, during the process of the order on behalf of

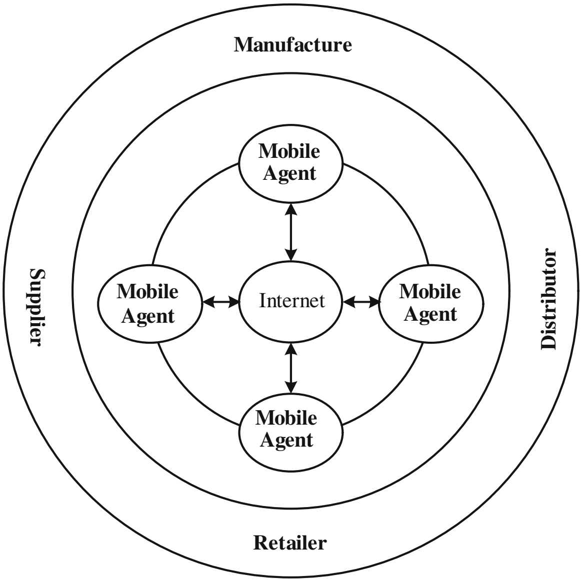

Fig. 124.1 Supply chain system operating framework based on mobile agent

the customers' needs flows in the supply chain, it will be converted into various orders, such as production order, transportation order, etc., and be dispatched to each corresponding node for information processing and interaction.

Using mobile agent to represent ordered object can take advantage of the characteristics of mobile agent and dispatch mobile order agent to different areas to carry out missions, exchange information with each node on local machine, and then avoid mass data transferring in the network, at the same time, balance the load of each node, improve the efficiency of information transmission, achieve information sharing, maintain the integrity, real-time and dynamic of information.

According to the above analysis, a supply chain management system model based on mobile agent is built, as shown in Fig. 124.2. In this model, through Internet, mobile agent moves among suppliers, manufacturers, distributors and retailers to realize coordination management between enterprises on supply chain.

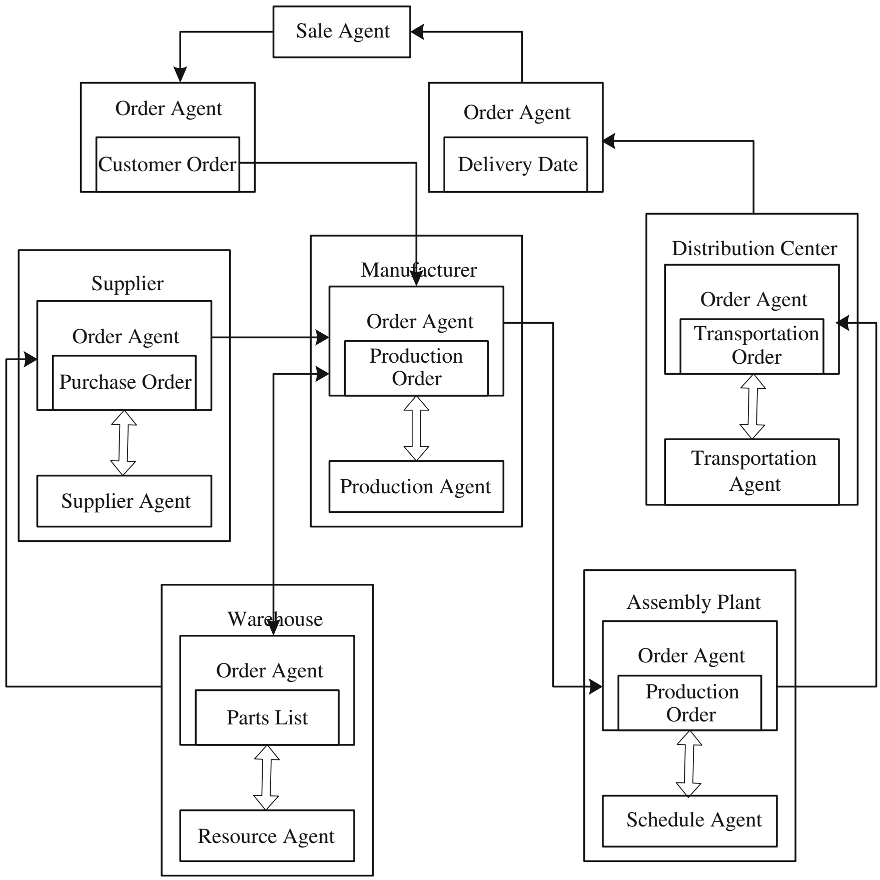

Fig. 124.2 Supply chain management system model based on mobile agent

124.2.5 Technology Advantages of Using Mobile Agent

Compared with traditional supply chain management model, the supply chain management model based on mobile agent has significant advantages, mainly shown in the following aspects:

(1) Distributed character: A group of platform-independent mobile agents with different features undertake various functions of supply chain management.
(2) Dynamic: Different from batch processing and sectional processing, each agent has an asynchronous processing function.
(3) Intelligence: Because each agent has the artificial intelligence feature, it is the expert in this functional field.
(4) Integrity: Each agent can sense the function scope of other agent, and can easily get the same function.
(5) Responsiveness: Each agent has the dual role as client and server, that is to say, it can obtain information from other agents and also can send information to other agents.
(6) Reactivity: Different from prefabricated and lack of flexibility response, each agent can make appropriate response and adjust its behavior according to different situations.
(7) Completeness: The total set of agent functions can cover all supply chain related functions.
(8) Repeatability: Supply chain management can support and adapt to the subset of agent.
(9) Backward Compatibility: Agent can be seamlessly upgraded, so that the new or modified features do not undermine the existing framework or function.

124.3 Several Key Issues of System Realization

124.3.1 Life Cycle Management of Agent

As mentioned above, in different stages of the project life cycle, each agent completes various functions, so the establishment of each project needs to dispatch various agents. After dispatching each agent, it will be copied and distributed continuously in the network. The number of agents will grow exponentially, and then lead to the occupation of network and computing resources, eventually lead to paralysis of the entire network. Therefore, in addition to complete of a task and remove it in time, we also need to restraint replication frequency and survival time of agent. At the same time, we also need to identify the agent uniformly, ensure that there is only a copy of the agent in each site (Li et al. 2003).

124.3.2 Information Exchange Between Agents

Order agent is a key agent in the system and interacts with other static agents using ACL (Agent Communication Language). ACL is a kind of language based on speech act theory, which defines the syntax and semantics of negotiation process between agent and service facilities.

124.3.3 Migration Mechanism

Migration Mechanism is one of the core technologies in supply chain management system based on mobile agent. Agent's travel method includes command method and plan method. In command method, agent system provides a travel command, by calling this command the agent can travel to any destination with some additional parameters such as destination address. This is a high flexible method and of strong ability, it can express any travel requirements. Another method expresses travel requirements through a travel plan. In this method, agent's travel information will be more clear and easy to understand and manage.

124.3.4 Migration Failure

In the process of migration to the destination, the mobile agent may encounter all kinds of troubles called migration failure. In order to solve the problem of migration failure, we applied a specialized mechanism to ensure the agent's normal migration when the network failed, that is the function of the Dock system (Jie 2006), as shown in Fig. 124.3. Its implementation reflects the characteristics of mobile computing, and enhances the robustness of the system.

124.3.5 System Security

The system security includes two aspects: one is the protection of the host of running mobile agent or entity from malicious attacks, and the other is the protection of mobile agent from the attacks of malicious running environment and hostile agents (Liu et al. 2001). These two aspects are contradictory to some extent, that is, the solution of one problem will increase the difficulties of the solution of another one. Among them, the second problem is particularly challenging. The security of mobile agent requires extensive research, and only to solve the problem, it will be widely used and of great value.

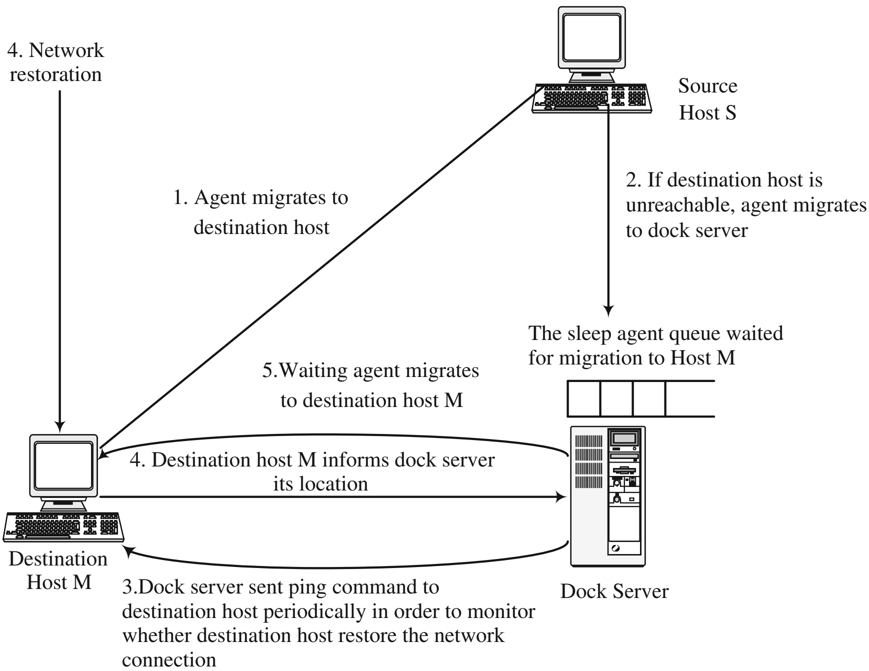

Fig. 124.3 Work flow of dock system

124.4 Conclusion

The introduction of mobile agent to supply chain can link the distributed agents and make each node of distributed supply chain intelligent and dynamic, and it has the ability to solve large scale problems. It also will strengthen the information transmission speed and sharing degree of each links of supply chain network, and then enhance the agility of supply chain and the quick response ability, resolve the problems of supply chain optimization, collaboration, coordination and etc., reduce the bullwhip effect. The introduction of mobile agent provides a new way for supply chain management and enterprise information system integration. It has a great practical value for further research of enterprise supply chain management system. However, there are many specific issues needed further refinement, and the security, reliability and fault tolerance of system remain to be further studied.

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Chapter 125
Research on the Supplier Selection Based on Multi-Target Semi-Structure Fuzzy Recognition Decision Theory

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Abstract Selecting suppliers is the core issue in supply chain management. In order to take full account of both quantitative and qualitative targets, reduce the interference of human factors and get a more rational and scientific decision, we propose a new suppliers' selecting decision method based on multi-target semi-structure fuzzy recognition theory in this paper to make a decision on the quantitative and qualitative targets. We also verify its feasibility in the problem of suppliers' selection through a case study.

Keywords Fuzzy optimal membership · Multi-target semi-structure · Supplier · Weight

125.1 Introduction

Nowadays, more and more enterprises are paying attention to cultivating core competence and expanding core business. So it is becoming a trend to obtain resources from outside through outsourcing. From the point of integrated supply chain and system theory, we put supplier in the network structure model of a supply chain, and manufacturing resources is the input of the whole system. However, the behavior of suppliers and the standard of production elements market have a close relation with the quantity and quality of manufacturing resources. Therefore, how to select a supplier has become the core problem

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concerned by each enterprise (Ma 2010). There are varieties of factors affecting the selection of suppliers. If we cannot fully understand the information of each factor, it is difficult for us to define the relation between each factor and the final results even though we are quite sure with each factor, since most of the factors are qualitatively described, which affects the reasonability, accuracy and scientificity in selecting suppliers. Currently, a number of methods have been put forward one after another, such as ABC cost method, Analytic Hierarchy Process (APH) (Sarkis and Talluri 2002; Zhu 2005), Data Exchange Analytic (DEA) (Liu et al. 2004; Lou et al. 2002), Artificial Neural Network (ANN) (Zhao and Sun 2002; Du 2008) and so on. In this paper, we take advantage of the fuzzy recognition decision theory based on multi-target semi-structure (Chen 2001a) to set suppliers' optimal decision model for suppliers' comparison. We take each factor relating to evaluation as targets to establish a supplier selecting system under the total objective. Then the multi-objective semi-structure fuzzy recognition decision theory will be utilized to convert qualitative targets into target relative membership degree, and all the quantitative targets and qualitative targets will be included into decision-making model for a more reasonable and scientific decision.

125.2 The Establishment of Systematic Structure Index System about Selecting Suppliers

In the management of supply chain, there are four key factors concerning selecting suppliers should be carefully dealt with. They are production quality, production price, delivery reliability and service. Meanwhile, some other factors such as production development and manufacture of suppliers, the external environment of supplier, etc. should also be taken into consideration (Liu et al. 2004). However, different enterprises differ from each other. Therefore, the selection of suppliers should be made on the basis of reality. The supplier selecting system under total objective is shown in Table 125.1.

In all these objectives, Rate of defective products (C1), Sample survey (C2), Production price provided by suppliers (C5), Quantity discount (C6), Transportation cost (C7), Delivery time of suppliers (C8), Expand delivery capacity (C9), Capacity of receiving emergent order (C10), Capacity and speed of technology research and development (C14) and geographic position (C18) can be reflected by the statistics or estimates, they are quantitative objectives. And other indicators are impossible or difficult to be calculated or estimated, so they are qualitative objectives.

Table 125.1 The supplier selecting system under total objective

The best supplier (A)	Quality (B1)	Rate of defective products (C1)
		Sample survey (C2)
		Total quality control (C3)
		Quality system certification (C4)
	Price (B2)	Production price provide by suppliers (C5)
		Quantity discount (C6)
		Transportation cost (C7)
	Delivery (B3)	Delivery time of suppliers (C8)
		Expand delivery capacity (C9)
		Capacity of receiving emergent order (C10)
	Service (B4)	Service standard (including transportation and package) (C11)
		Capacity of communication and feedback (C12)
		Capacity of improving service (C13)
	Production development and manufacture (B5)	Capacity and speed of technology research and development (C14)
		Strain capacity for new technology (C15)
		Current capacity of manufacturing machine (C16)
		Adaptive capacity for the process change of supplier (C17)
	External environment (B6)	Geographic position (C18)
		Tariff and drawback policy of home country (C19)
		Political stability and its relative economic policy of the home country (C20)
		Currency exchange rate of the home country (C21)

125.3 Multi-objective Semi-structure Fuzzy Recognition Decision of Selecting Suppliers

An Optimum set is composed by all the suppliers selected by an enterprise. If the number of suppliers is n, then the set can be

$$d = \{d_1, d_2, \ldots, d_n\} \tag{125.1}$$

The feature of sample (i.e. each supplier) j is represented by m target Eigen value (m is the number of target Eigen value). It is

$$x_j = \left(x_{1j},\ x_{2j},\ x_{3j}, \ldots, x_{mj}\right)^T \tag{125.2}$$

The number of quantitative target is α, and the number of qualitative target is β.

Then the sample set can be expressed by target Eigen value matrix m $\times$ n rank, that is

$$X = \left(x_{ij}\right) \tag{125.3}$$

In the target Eigen value matrix m × n rank, there is a quantitative target Eigen value matrix and a qualitative target Eigen value matrix, that is

$$ {}_1X = \left({}_1x_{ij}\right) \tag{125.4} $$

$$ {}_2X = \left({}_2x_{ij}\right) \tag{125.5} $$

${}_1$X is a quantitative target Eigen value matrix and ${}_2$X is a qualitative target Eigen value matrix. x_{ij} is the Eigen value of target i of sample j; $i = 1, 2, 3, \ldots, m$; $j = 1, 2, 3, \ldots, n$.

125.3.1 Defining the Relative Optimal Membership Degree of Quantitative Target

Those quantitative targets for selecting suppliers are generally divided into two types. One is the type whose Eigen value is the bigger the better; the other is the type whose Eigen value is the smaller the better (Jia and Yin 2012). The transformation of relative membership degree can be realized by utilizing formulas (125.6) and (125.7).

When quantitative target belongs to the first type, i.e. the bigger the better, the relative optimal membership degree formula is

$$ r_{ij} = \frac{x_{ij}}{\max x_{ij}} \tag{125.6} $$

When quantitative target belongs to the second type, i.e. the smaller the better, the relative optimal membership degree formula is

$$ r_{ij} = \frac{\min x_{ij}}{x_{ij}} \tag{125.7} $$

Through (125.4) and (125.5), target Eigen value matrix (125.4) ${}_1X = \left({}_1x_{ij}\right)$can be the relative optimal membership matrix

$$ {}_1R = \left({}_1r_{ij}\right) \tag{125.8} $$

125.3.2 Defining the Relative Optimal Membership Degree of Qualitative Target

As for those descriptions toward the quantitative target of each supplier, we can define its fuzzy scale matrix through the following Table 125.2, a table for correspondence established between mood operator and fuzzy scale value (Tam et al.

Table 125.2 Table for correspondence established between mood operator and fuzzy scale value

A mood operator	Fuzzy scale value
Equal	0.5
A little more	0.55
Slightly	0.60
Relatively	0.65
Evidently	0.7
Notably	0.75
Fully	0.8
Very	0.85
Extraordinarily	0.9
Extremely	0.95
Excellently	1

2006) in the way of duality comparison. Next, the scale Eigen value matrix of the relative optimal membership degree of qualitative target can be obtained by A_i, which is ${}_2X = \left({}_2x_{ij}\right)$.

$$ {}_2r_{ij} = \frac{{}_2x_{ij}}{\max_{j2} x_{ij}} \tag{125.9} $$

We can obtain the relative optimal membership matrix of qualitative target ${}_2R = \left({}_2r_{ij}\right)$.

Therefore, the relative optimal membership matrix of quantitative and qualitative target is $R = \left(r_{ij}\right)$.

125.3.3 Defining the Target Weight

At first, we should define the weight of tertiary target, then define the sequence of importance by quality comparison. This is the importance of each tertiary target, which is correspondent with each secondary target toward. Finally we have the sequence of tertiary target by carrying out the consistency test. After calculating each weight respectively, the non-normalization weight vector of tertiary target toward, and normalization weight vector will be solved. Then, we can get the weight vector of secondary target by the same way.

125.3.4 Defining the Relative Membership Degree Regarding the Excellency in Optimum Set

On the basis of the data obtained above, we can utilize the following fuzzy optimization theoretical model (Chen 2001b).

$$u_j = \frac{1}{1 + \left(\frac{d_{jg}}{d_{jb}}\right)^{\alpha}} \tag{125.10}$$

In $d_{jg} = \left\{ \sum_{i-1}^{m} \left[\omega_i \left(1 - r_{ij}\right)\right]^p \right\}^{\frac{1}{p}}$ and $d_{jb} = \left\{ \sum_{i-1}^{m} \left[\omega_i \left(r_{ij} - 0\right)\right]^p \right\}^{\frac{1}{p}}$, if $\alpha = 1, p = 2$, we can get secondary target $B_i(i = 1, 2, \ldots, 6)$ regarding the excellency of n suppliers in secondary target, that is ${}_iu(i = 1, 2, \cdots, 6)$. Then the matrix of relative membership degree regarding the excellency in secondary target can be produced as $R = \left(r_{ij}\right)$, $i = 1, 2, \cdots, 6; j = 1, 2, \cdots, n$. If the weight of secondary target ω and the data of matrix R substitute in 5-level fuzzy recognition model $S = (\,1 \quad 0.8 \quad 0.6 \quad 0.3 \quad 0\,)$, the fuzzy recognition theory model (Chen 2001c) can be utilized.

$$u_{hj} = \begin{cases} 0 & h < a_j \bullet h > b_j \\ \left(d_{hj}^{\alpha} \sum_{k=a_j}^{b_j} d_{kj}^{-\alpha} \right)^{-1}, & d_{hj} \neq 0, a_j \leq h \leq b_j \\ 1 & d_{hj} = 0 \bullet r_{hj} = s_{ih} \end{cases} \tag{125.11}$$

And the parameter $\alpha = 1$, P = 2, we can have the relative optimal membership matrix $u = \left(u_{hj}\right)$, $h = 1, 2, \ldots 5$; $j = 1, 2, \ldots, n$, which is made for the optimum set to the 5 levels. From the level Eigen value model, the solution of the level Eigen value vector $H = \left(h_{1j}\right)$, $j = 1, 2, \ldots, n$, for n suppliers can be get. And the supplier corresponding to the smallest level Eigen value will be the optimal supplier.

125.4 Case Study

A certain production-manufacturing enterprise wants to select a cooperative partner among those six components suppliers. The production-manufacturing enterprise takes the four secondary goals of Table 125.1 into consideration. They

Table 125.3 The quantitative target values of each supplier

Supplier	d_1	d_2	d_3	d_4	d_5	d_6
C_1 (%)	8	2	10	1	13	14
C_2 (%)	96	95	95	98	96	98
C_5 (RMB)	225	208	200	235	215	212
C_6 (%)	10	5	10	5	10	10
C_7 (RMB/ton·km)	0.5	0.55	0.6	0.5	0.5	0.5
C_8 (day)	19	20	22	24	23	21
C_9 (%)	100	100	100	95	90	100
C_{10} (%)	95	95	90	100	100	95

are quality (B1), price (B2), delivery (B3) and service (B4). Besides, those tertiary sub-goals required when analyzing secondary goals should also be considered. And the quantitative target values of each supplier can be found in Table 125.3.

The quantitative target values C2, C6, C9 and C10 belong to the type of the bigger the better, and C1, C5, C7 and C8 belong to the type of the smaller the better. Then, we can get the relative optimal membership degree matrix of quantitative target by using formula (125.6) and (125.7).

$$
{}_1R = \begin{array}{c} \begin{matrix} d_1 & d_2 & d_3 & d_4 & d_5 & d_6 \end{matrix} \\ \begin{pmatrix} 0.13 & 0.50 & 0.10 & 1.00 & 0.08 & 0.07 \\ 0.98 & 0.97 & 0.97 & 1.00 & 0.98 & 1.00 \\ 0.89 & 0.96 & 1.00 & 0.85 & 0.93 & 0.94 \\ 1.00 & 0.50 & 1.00 & 0.50 & 1.00 & 1.00 \\ 1.00 & 0.91 & 0.83 & 1.00 & 1.00 & 1.00 \\ 1.00 & 0.95 & 0.86 & 0.79 & 0.83 & 0.90 \\ 1.00 & 1.00 & 1.00 & 0.95 & 0.90 & 1.00 \\ 0.95 & 0.95 & 0.90 & 1.00 & 1.00 & 0.95 \end{pmatrix} \end{array} \begin{matrix} c_1 \\ c_2 \\ c_5 \\ c_6 \\ c_7 \\ c_8 \\ c_9 \\ c_{10} \end{matrix}
$$

The fuzzy scale value of qualitative targets C3, C4, C11, C12 and C13 can be defined based on Table 125.2, thus producing the scale Eigen value matrix of those qualitative targets. Next, the relative optimal membership degree matrix for qualitative targets will come into being by using formula (125.9).

$$
{}_2R = \begin{array}{c} \begin{matrix} d_1 & d_2 & d_3 & d_4 & d_5 & d_6 \end{matrix} \\ \begin{pmatrix} 1.00 & 0.91 & 0.82 & 0.74 & 0.56 & 0.38 \\ 1.00 & 0.91 & 0.82 & 0.74 & 0.57 & 0.39 \\ 1.00 & 0.90 & 0.81 & 0.76 & 0.71 & 0.66 \\ 0.66 & 0.71 & 0.76 & 0.81 & 0.90 & 1.00 \\ 0.33 & 0.59 & 0.68 & 0.78 & 0.91 & 1.00 \end{pmatrix} \end{array} \begin{matrix} c_3 \\ c_4 \\ c_{11} \\ c_{12} \\ c_{13} \end{matrix}
$$

The relative optimal membership degree matrix R of quantitative and qualitative targets can thus be produced. Then, the relative optimal membership degree will be listed in Table 125.4.

According to the principle of duality comparison, we establish an importance qualitative sequencing matrix of tertiary targets to secondary targets. Then, a test for consistency will also be carried out to get the non-normalization weight vector of tertiary targets. By normalizing, the weight of each tertiary targets will be obtained, and the weight of secondary targets can also be acquired by the same way, and listed in Table 125.4.

With the help of data in Table 125.4, we can gain the relative degree of membership concerning excellency for the six suppliers by utilizing Fuzzy Optimum Seeking Theory model (125.10).

Table 125.4 The relative optimal membership degree of targets and their weight

Weight of secondary targets	Secondary targets	Weight of tertiary targets	Tertiary targets	Relative optimal membership degree of targets					
				d_1	d_2	d_3	d_4	d_5	d_6
0.438	B_1	0.438	C_1	0.13	0.50	0.10	1.00	0.08	0.07
		0.312	C_2	0.98	0.97	0.97	1.00	0.98	1.00
		0.125	C_3	1.00	0.91	0.82	0.74	0.56	0.38
		0.125	C_4	1.00	0.91	0.82	0.74	0.57	0.39
		0.556	C_5	0.89	0.96	1.00	0.85	0.93	0.94
0.312	B_2	0.111	C_6	1.00	0.50	1.00	0.50	1.00	1.00
		0.333	C_7	1.00	0.91	0.83	1.00	1.00	1.00
		0.556	C_8	1.00	0.95	0.86	0.79	0.83	0.90
0.187	B_3	0.222	C_9	1.00	1.00	1.00	0.95	0.90	1.00
		0.222	C_{10}	0.95	0.95	0.90	1.00	1.00	0.95
		0.556	C_{11}	1.00	0.90	0.81	0.76	0.71	0.66
0.063	B_4	0.111	C_{12}	0.66	0.71	0.76	0.81	0.90	1.00
		0.333	C_{13}	0.33	0.59	0.68	0.78	0.91	1.00

$$R = \begin{array}{c} \begin{matrix} d_1 & d_2 & d_3 & d_4 & d_5 & d_6 \end{matrix} \\ \begin{pmatrix} 0.484 & 0.649 & 0.461 & 0.923 & 0.441 & 0.432 \\ 0.908 & 0.902 & 0.918 & 0.853 & 0.941 & 0.950 \\ 0.983 & 0.953 & 0.874 & 0.820 & 0.850 & 0.912 \\ 0.716 & 0.783 & 0.770 & 0.766 & 0.755 & 0.729 \end{pmatrix} \end{array} \begin{matrix} B_1 \\ B_2 \\ B_3 \\ B_4 \end{matrix}$$

If we introduce secondary target weight in Table 125.4 and the relative degree of membership matrix R concerning excellency for the six suppliers into 5-level fuzzy pattern recognition model like formula (125.11), we can see the relative degree of membership matrix of the six suppliers to the 5 levels as follows.

$$U = \begin{pmatrix} 0.172 & 0.190 & 0.165 & 0.341 & 0.166 & 0.170 \\ 0.268 & 0.379 & 0.257 & 0.408 & 0.251 & 0.251 \\ 0.301 & 0.254 & 0.309 & 0.138 & 0.302 & 0.295 \\ 0.161 & 0.110 & 0.169 & 0.068 & 0.175 & 0.176 \\ 0.098 & 0.069 & 0.101 & 0.045 & 0.106 & 0.108 \end{pmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{matrix}$$

Based on the formula of Level Eigen value, we can get $H = (2.745\ 2.495\ 2.787\ 2.068\ 2.804\ 2.801)$. From this, the optimal sequence of these six suppliers is d_4, d_2, d_1, d_3, d_6, d_5. Therefore, the best components supplier is d_4.

125.5 Conclusion

A number of factors need to be considered when selecting suppliers. Among them, there are a lot of qualitative methods. The multi-target semi-structure decision model are utilized to calculate the qualitative targets by the optimal mood operator in the way of duality comparison, which can significantly improve the accuracy of those qualitative factors, thus resulting in a more scientific and more reasonable selection.

It is more appropriate than the traditional method in selecting suppliers by combining both fuzzy optimum selecting method and fuzzy recognition method.

Acknowledgments We would like to record my gratitude to Shanshan Xu and Jing Li for their advice, proofreading, and crucial contribution. It is a pleasure to convey our gratitude to them in our humble acknowledgement.

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Chapter 126
Research on the Model of Enterprise Full Property Management Based on Value Chain Theory

Fan-fang Wen, Peng-yang Liu and Ping Li

Abstract According to the theory of value chain, this paper builds the "full property management" value chain model, analyses the value-added system of the "full property management" value chain, and researches the value-added contribution to the property management companies as well as other activities on the value chain. At last, proposing the optimized value chain's countermeasure by implementing value chain management, which provides a reference for the win–win of property management companies, developers, property suppliers and owners.

Keywords Full property management · Property management companies · Value-added · Value chain

126.1 Introduction

With the appearance of national real estate macro-control policy and financial macro-control policies, profound changes occur to the real estate value chain, the real estate industry can't achieve the purpose of funding rapid return by land acquiring, building, marketing or quickly copy. The real estate industry now pays more attention to energy saving, environmental protection, science and technology, and pay more attention to the property services. Real estate gradually develops from the product competition stage to service competition stage.

To create a superior property service system, many developers and property management companies began to call "early intervention" of property management. However, because the property management service concept is not high

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enough, "early intervention" only emphasizes that property management must be involved in real estate development phase advance, but there is no continuity before and after the clear property services, resulting in lack of systematic and consistent in all stages of property management. Consequently, finding a suitable property development management model is urgent to developers, property management companies and property demanders.

126.2 Construction of Model of Full Property Management Based on Value Chain Theory

126.2.1 Construction of Property Management Companies' Value Chain

By detailed analysis of the business processes of domestic property management companies, combined with Porter's "value chain analysis", current property management business value chain model can be summed up (Fig. 126.1).

The basic activity of property management companies and Potter (internal logistics, production and management, external logistics, marketing and sales, service) (Feng 2005) is different, but they are both divided by the dynamic process of value created. In which, early intervention, pre-property and normal property is a modern property management advocated called "full property management",

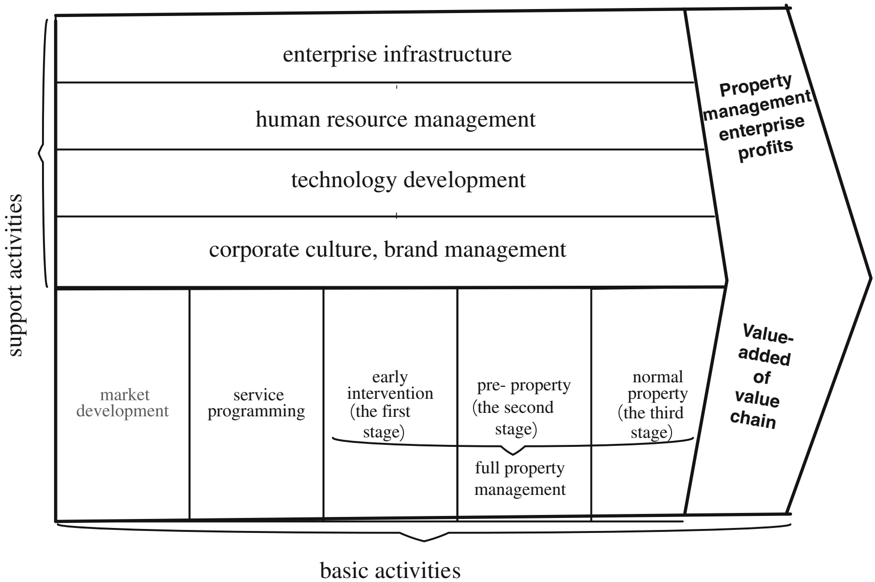

Fig. 126.1 The "full property management" value chain model

which early intervention, the previous property, the organic combination of the three stages of the late property is a modern property management advocated the "full property management", so this model called the " full property management" value chain mode below.

126.2.2 Definition of the Basic Activities of the "Full Property Management" Value Chain

Basic activities in the value chain create and increase the external customer value for companies (Wang 2004), so focusing on defining basic activities of value chain.

1. Market development
   Market development is the first step for the property management enterprises to enter the real estate development project, property management companies participate in the bidding of the target management project, and prepare for the process of advertising and looking for partners in the background of preliminary research of the target items, conditions, types of market conditions.
2. Service programming
   Service programming is to develop a full property management services as a reference for the subsequent full property management job. Full property management service planning (Peng 2006) in order to meet customer needs, to grasp the whole process of customer needs, including the argument from the real estate investment, planning and design, construction to marketing and sales, the occupation of the property management and day-to-day management, which occur in all aspects of real estate development; according to the planning design of realty service objectives, strategies, technology and operation, reach property management services target.
3. Full property management
   Depending on the property management companies at different stages of objects and services, full property management is divided into three stages.

   (1) Early intervention
   Early intervention refers to the property management companies invited or commissioned by the developer's property early intervention contract, signed with the developer to provide useful and constructive advice from the perspective of property management services and property owners in the investment, planning, design, construction phase, to help developers to control planning and design, construction, engineering quality and function using, to ensure that the design and construction quality of the property, to create conditions for the property owners, and to avoid the risk of service. Early interventions of property management have a profound impact both

on the development of the project and the latter part of the routine management.

(2) Pre property
Under “Property Management Regulations”, pre property means “management behavior that before owners and owners’ meeting hire a property management enterprise, the construction unit hires a property management enterprise”. It mainly related to the property to undertake acceptance, including the district acceptance and owner occupancy acceptance. In addition, the Organization warranty, repair and maintenance, and organize district archives. This stage is significant for the property management companies. Under “Property Management Regulations”, after owners’ committee is established, owners can choose their own property management companies by biding. Therefore, if property management companies can enter the next stage, to proceed with normal property management and services, and if the “full property management” value chain can shape, directly depend on if pre property is accepted by owners.

(3) Normal property
After owners all move in, owners’ committee is established which mark normal property management is coming. At this stage, service is the focus of property management. Staff in the details of the specific property management services to owners as the center for the owners to provide public services and personalized service to achieve the owners to maximize the value and emphasis on the social and cultural construction, and actively building a property brand. It is thus clear that three stages of the “full property management” are the key activities of value chain.

126.2.3 Analysis of Value-Added System of the” Full Property Management” Value Chain

Early intervention, pre property and normal property, which constitutes the “full property management”, is the key activities of the value chain and contribute most to value-added. According to the analysis of value-added system of Fig. 126.2, it can also be seen that the “market development” and “service programming “ activities only contribute for the value chain to comprehensive value–added and planning value–added, while the three stages of the “full property management” contribute to quality, technology, service, product and brand value–added. Therefore, to analyze value-added system of the “full property management” value chain, is also a study of early intervention, pre property and normal property these three stages how to add value to the value chain.

1. “Early intervention” value-added
In the stage of early intervention, active participants of the value chain relates to property management companies and developers. Early intervention can be

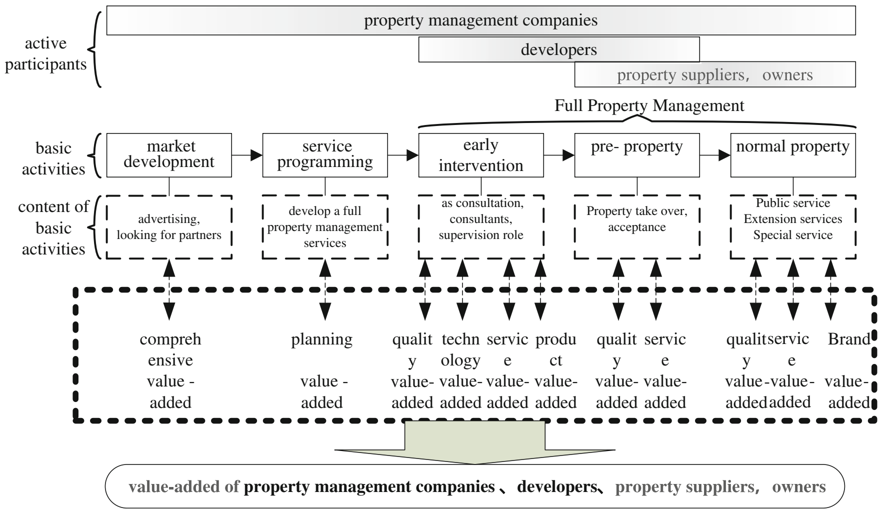

Fig. 126.2 Value-added system of the "full property management" value chain

divided into project decision-making Intervention, planning and design intervention, construction and installation intervention, sales planning Intervention and take over preparing Intervention five parts. All parts of intervention can contribute to the value added of the value chain.

2. "Pre property" value-added

   Early intervention work is mainly checking before Acceptance. Besides, there will be some owners check in, and where there are owners there are naturally to be the property suppliers. The preproperty activities involve property management companies, developers, property suppliers and owners—four active participants. Property management companies find some quality defects in the checking before acceptance, and timely feedback and urge to address these shortcomings. On the one hand, to promote real estate product value-added; on the other hand, to enhance the products purchased by the owners of their level of satisfaction and own customer delivered value.

3. "Normal property" value-added

   In the stage of normal property, it mainly related to property management companies, property suppliers and owners—three active participants. When property management companies accumulate a certain brand and customer resources, they can be located in property Integrated Provider on the basis of a certain brand and customer resources accumulation. They can integrate of owner demand information and property suppliers supply information. Efficient and thoughtful service organizations promote quality and service value-added of property management companies and property suppliers, to enhance the brand value of product and property management companies, and ultimately realized owners' value.

   By Fig. 126.2 and the above analysis, property management enterprises implement the model of full property management based on value chain theory, through system operation of early intervention, pre property and normal property there three key activities, to realize value-added of "full property management" value chain and four value chain active participants (property management companies, developers, property suppliers, owners) (Wang et al. 2006).

126.3 Countermeasures to Optimize the Full Property Management Value Chain

Since "full property management" is value-added activities in the value chain, to optimize the value chain, to ensure the smooth running of the value chain, to make sure value chain value-added sostenuto, only depends on the implementation of effective value chain management to full "property management".

126.3.1 To Form the Integrated Value Chain

The nature of value chain management is to optimize the business processes and improve the core competitiveness of enterprises (Zhang 2001). By the integrated control of information flow, service flow and capital flow which throughout the value chain, from the contract signed to provide services (Dong and Fei 2011; Richard 2004), and finally the service sent to the owners hands, link developers, property management companies, property suppliers and owners together into a whole network chain model. This is not only a value chain of information flow (Mathew 2009; Hawkins et al. 2001), service flow and capital flow which can connect each value active participants, but an overall value-added chain.

126.3.2 To Establish a Value Chain Management of Customer-Oriented Relationship

To the successful implementation of value chain management, it is necessary to change the traditional organizational structure (Svetlana 2007; Winston 2008). Clients (owners) is the end of the value chain of property management companies, is the starting point of capital flow and information flow, the end of service flow. Realization of customer (the owner) value is the key to the smooth functioning of the value chain. Using concept of customer relationship management to establish a new owner department–customer service center (customer service needs call center) within the organization of property management companies (Giersch 1997;

Eddie et al. 2002). When owners need service, just issued a demand for the service information to the customer service center, customer service center classifies the needs of the owners.

126.3.3 To Implement Integration Model of Property Construction and Management

Value chain management also needs the choice of the most appropriate cooperation model of value chain active participants. Implementation of early intervention, and the property management companies involved in real estate development in the decision-making stage, early intervention costs paid by the developer, but due to the current legal system of" early intervention" is not perfect (Wang 1988). The developer's aspiration for early intervention is not high, so the property management business interests easily damaged. Finally enhance the real estate developers brand reputation (Wheaton 1999), and realize the real estate-property brand a win–win situation.

Some well-known developers such as China Vanke and Long-Hu both use property construction and management integration mode. What can be referenced is, Vanke practice strategic cooperation patter of "form independent, the direction unity", form independent is to point to have independent operation Vanke property system, and real estate remain relatively independent Vanke development space and pattern of development, the direction unity is to point to the property with the unity of Vanke brand, in order to create different Vanke products which meet customer demand for the same direction (Dong and Fei 2011)·

126.3.4 To Improve the Property Early Intervention Related Laws and Regulations

Finally, if value chain management system is perfect, depends on if the relative legal system is perfect. The "full property management" includes early intervention, pre- property and normal property three parts. "Property Management Regulations" empowers guaranteed rights to participants in pre property and normal property, but there are few norms which involves the interests of property management enterprise and developers in the stage of early intervention. As the panegyric of "full property management" model, the author suggests the government departments gradually establish and perfect the relevant laws and regulations, making there are laws to abide by "early intervention".

126.4 Conclusions and Prospect

From the perspective of property management service coherence, model of full property management based on value chain theory is proposed. The key to add value is to implement effective property management enterprise which put the "full property management" as activities throughout the property management value chain, continue to improve the property value chain management, and promote the sustainable development of the property management industry, make property management do "customer satisfaction, enterprise satisfactory, social satisfaction".

In addition, this paper just links four main active participants(property management enterprise, developers, property suppliers, owner) to value chain, but not list government, property management enterprise internal employees and other property management enterprise to the influence of the value chain. There are some limitations in the study, and further discussion is needed.

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Chapter 127
Research on the Strategic Alliance Between Hospitals and Suppliers Based on Evolutionary Game Theory

Yan Wen, Jing Peng and Peng Tong

Abstract This paper analyzes the evolution process to build strategic alliance between hospitals and suppliers based on evolutionary game theory. The first stage, the single group evolutionary game is used to analyze the situation whether the hospitals or suppliers will select the cooperative strategy and build the supply chain strategic alliance. The second stage, double groups' evolutionary game theory is adopted to demonstrate the evolution process of the cooperation relationship between hospitals and suppliers. At last, the related parameters which influence the equilibrium of are analyzed.

Keywords Cooperation · Evolutionary game theory · Hospitals · Supply chain · Strategic alliance

127.1 Introduction

With the rise of supply chain management, the hospital administrators began to understand the idea of "cooperation", "win-win". By means of building strategic alliances with the suppliers, and realizing seamless link between internal supply chain and external supply chain (Jayaraman et al. 2000), the hospital can achieve to stable supply source, reduce the purchase cost, shorten the response time, and

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finally enhance the competitiveness. Supply chain strategic alliance is a new type of enterprise cooperation mode under the integrated management environment and a embodiment of the external integration with the suppliers (Wen et al. 2010).

Game theory is used to study and explain many aspects of the supply chain alliance, for example, formation and development, competition and cooperation, stability and compromise, etc. Parkhe (1993) thought strategic alliance constitutes a prisoners' dilemma for the enterprise's behavior choice essentially. Repeated games in the league led to another—a need to solve the conflict, that is short and long term cooperative behavior. Xu and Ma (2000, 2001) gave a general trust game model under the background of the social system based on the game analysis of the trust relationship between the supply chain partners. Zhang et al. (2008) analyzed the causes of the supply chain alliance, a proposed that only when all of the alliance members can obtain the highest overall benefit through the application of Nash equilibrium principle. Han and Guo (2003) studied the profit distribution mechanism of dynamic alliance based on prior consultation. Above scholars analyzed strategic alliance of supply chain by means of the traditional cooperative and Non-cooperative game theory, which require higher rationality for the main game body. But in fact, the enterprise members in strategic alliance is limited rational, the information is not complete, the game equilibrium and evolutionary process often show the characteristics of complexity in the process of cooperation and competition, and the enterprises don't have the ability of choosing the best.

Evolutionary game theory is the theory of combining game analysis with dynamic evolution process (Xie 2001), it considers that individuals are not completely rational but limited rational, and not an individual's decision is realized by the dynamic process of imitation, learning, and mutation between each other (Weibull 1995). Long (2008) analyzed the relationship between the members of supply chain partner using evolutionary game model, and pointed out that the evolutionary process of the partnership is related with the members cooperation preference. Johnston et al. (2004) and Handfield and Bechtel (2002) study influence factors and the relationship of measure indexes of the trust between the supply chain enterprises. Ye and Zhang (2006) analyzed the key factors in distribution channel of automobiles in order to explain the problems that may rise the cooperation, such as inefficient cooperation and insecure symbiosis, using the evolutionary game theory. Most scholars analyzed problems based on the utility function using the game theory and evolutionary game theory. Using the transaction cost as analysis basis, this thesis tries to verify that building strategic alliances can reduce transaction cost between hospital and suppliers and get the benefit maximization of both sides from the point of view of evolutionary game.

127.2 The Single Group Evolutionary Model Mobile Whether the Suppliers Selecting the Cooperation Strategy

Over a period of time, supposed that *N* homogeneous suppliers for a hospital are a group, the hospital will purchase materials by establishing strategic alliance with part suppliers or traditional purchasing mode. We define *q* as the ratio of suppliers that are selected by hospital to establish strategic alliance, for a single supplier namely to probability to establish strategic alliance with hospital, then *1 – q* means the ratio of suppliers in the group dealing with hospital by traditional purchasing mode.

Before stating the model, we also need some other variables.

P, the probability of successful operation of strategic alliance,
1 – p, failure probability for strategic alliance,
R, expected return for the success,
M0, the loss of failure, that is, the investment for suppliers to building strategic alliances for negotiations and information platform construction,
ε, random variable that reflecting all the effects of other factors and subjecting to uniform distribution $(-\pi 0/2, \pi 0/2)$,
r1, the actual return is the functions of *R, q* and random variable ε, and r1 is the increasing function of *R*, decreasing function of *q*, a single supplier of the actual return decrease with the increase of suppliers entering the strategic alliance, the advantages disappear gradually (Li 2005; Zhao et al. 2009), namely,

$$r1 = f(R, q) + \varepsilon \tag{127.1}$$

Decision variables are as follows: $f(R,0) = 0, f(R,1) < R$. For $\mu \in (0,1)$, then $r1$ is

$$r1 = R(1 - \mu q) + \varepsilon \tag{127.2}$$

Expected return of supplier entering the strategic alliance is as follows:

$$E(r1) = R(1 - \mu q) \tag{127.3}$$

Return on investment when a failure: $r2 = -1$, expected return after building the strategic alliance is as follows:

$$E(r) = pR(1 - \mu q) + (1 - p)(-1) \tag{127.4}$$

If the supplier and hospital don't establish the strategic alliance, the benchmark interest is *r0*, Profits pay matrix for the single group game model is obtained (Table 127.1).

Suppliers adjust the selection probability for two strategies according to many times game in past (that is, if the statistical results show that the average pay of a strategy more than the average pay of hybrid strategy, supplier tend to choose this

Table 127.1 Profits pay matrix for the single group game model

	Establish the strategic alliance	Traditional purchasing mode
Expected return of successful strategic alliance (p)	$R(1-\mu q)$	$r0$
Expected return of failure of strategic alliance ($1-p$)	-1	
Expected return of establishing the strategic alliance	$pR(1-\mu q)+(1-p)(-1)$	
Expected return of group suppliers	$qpR(1-\mu q)+q(1-p)(-1)+(1-q)$	$r0$

strategy), and the relative adjustment speed of selecting a strategy is a direct ratio with the range of the income beyond a average pay, then the imitators dynamic equation of the system is as follows:

$$\frac{dq}{dt}=q(Er-E)=q(1-q)[pR(1-\mu q)+(1-p)-r0] \tag{127.5}$$

Get rid of the 0, 1 singular point solutions, the equilibrium solution of this system:

$$q^{*}=\frac{1-\frac{1-p+r0}{pR}}{\mu} \tag{127.6}$$

By formula (127.6), it is known that the equilibrium probability of suppliers selecting to build strategic alliance with hospital is a direct ratio with the probability of successful operation of strategic alliance and the expected return, and is a inverse ratio with opportunity cost for investment. Therefore, in order to encourage the suppliers to building strategic alliance and reduce their purchase cost, the hospital should share the information, take risk jointly, reduce the supplier number of similar materials, and build a reasonable interests assignment mechanism etc.

127.3 Double Group's Evolutionary Model

The first part analyses how the hospital take measures to encourage the suppliers to participate and cooperate to building the strategic alliance. In fact, these reasons often affect the cooperation relationship between hospital and suppliers, such as the information asymmetry, the unequal power, and insufficient ability of suppliers. The following part will analyses the cooperation relationship between the hospital and the suppliers by applying evolutionary game method, and find out the main factors of influencing evolution state from multiple evolution stable equilibrium.

127.3.1 Modeling Assumption

H, a set of medical institutions with the same grade in some area,
S, a set of suppliers with the homogenizes materials,
C_H, the hospital's purchasing cost of not building strategic alliances with the supplier,
Π_S, the profit of supplier's of not cooperating with hospital,
λ, interests keeping coefficient under the circumstance the hospital establish the strategic alliance and can reduce the purchase cost assuming that subject to uniform distribution in [0, 1] interval,
ΔC, the total purchasing cost to save for the hospital to establish the cooperation relations with suppliers,
ΔH, $\Delta H = \lambda \Delta C$, the actual purchase cost to save for hospital,
ΔS, $\Delta S = (1 - \lambda)\ \Delta C$, the interests distributed to the supplier by hospital,
δ_H, the hospital suffered cost loss when supplier doesn't provide adequate information to share after establishing the strategic alliance,
δ_S, the supplier suffered interest loss when hospital formulates the strong trade policies after establishing the strategic alliance.

The strategy set of both players are all the strategy implementation of the strategic alliance, (cooperation, cooperation) strategy means the hospital and suppliers establish strategic alliance, and both sides fully cooperate, the profit function is $(C_R - \Delta H, \Pi_S + \Delta S)$; (cooperation, non cooperation) strategy means the hospital and suppliers establish strategic alliance, but supplier doesn't provide adequate information to share, then the hospital may lose part of the purchase cost, the profit function is $(C_H + \delta_H, \Pi_S + \delta_H)$; (non cooperation, cooperation) strategy means the hospital and suppliers establish strategic alliance, but the hospital doesn't provide sufficient information to share, then the supplier will lose part of interest, the profit function is $(C_H - \delta_S, \Pi_S - \delta_S)$; (non cooperation, non cooperation) strategy means the hospital and suppliers don't establish strategic alliance, and the profit function is (C_H, Π_S).

127.3.2 References Evolution Equilibrium Analysis

Assume:

p, the probability of cooperation strategy in hospital set,
q, the probability of cooperation strategy in supplier set, we define fitness with interest.

For the hospital, the fitness for adopting a cooperation strategy is as follows:

$$f_R^1 = q(C_R - \Delta H) + (1 - q)(C_H + \delta_H) \tag{127.7}$$

The fitness for adopting a non-cooperation strategy is as follows:

$$f_R^2 = q(C_H - \delta_S) + (1-q)C_H = C_H - q\delta_S \tag{127.8}$$

The average fitness is:

$$f_R = pf_R^1 + (1-p)f_R^2 \tag{127.9}$$

For the supplier, the fitness for adopting a cooperation strategy is as follows:

$$f_S^1 = p(\Pi_S + \Delta S) + (1-p)(\Pi_S - \delta_S) \tag{127.10}$$

The fitness for adopting a non-cooperation strategy is as follows:

$$f_S^2 = p(\Pi_S + \delta_H) + (1-p)\Pi_S = \Pi_S + p\delta_H \tag{127.11}$$

The average fitness is:

$$f_S = qf_S^1 + (1-q)f_S^2 \tag{127.12}$$

Assumed the growth rate of proportion for individuals using a strategy in a group is equal to the relative fitness of this strategy, and then the development condition of this strategy is the fitness higher than the group average fitness.

The dynamic equation of the hospital selecting cooperation strategy is deduced from (127.7)–(127.9):

$$\frac{dp}{dt} = p(f_R^1 - f_R) = p(1-p)(f_R^1 - f_R^2) \tag{127.13}$$

The dynamic equation of the supplier selecting cooperation strategy is deduced from (127.10)–(127.12):

$$\frac{dq}{dt} = q(f_S^1 - f_S) = q(1-q)(f_S^1 - f_S^2) \tag{127.14}$$

The continuous power systems is deduced from (127.9), (127.10)

$$\begin{cases} \frac{dp}{dt} = p(f_R^1 - f_R) = p(1-p)(f_R^1 - f_R^2) \\ \frac{dq}{dt} = q(f_S^1 - f_S) = q(1-q)(f_S^1 - f_S^2) \end{cases} \tag{127.15}$$

That is

$$\begin{cases} \frac{dp}{dt} = p(1-p)[-q\Delta H + (1-q)\delta_H + q\delta_S] \\ \frac{dq}{dt} = q(1-q)[p\Delta S - (1-p)\delta_S - p\delta_H] \end{cases} \tag{127.16}$$

Formula (127.16) shows,

(1) $p = 0$, $p = 1$ or $q = \frac{\delta_H}{\delta_H + \Delta H}$, $\frac{dp}{dt} = 0$, namely selecting cooperation strategy for hospital is stable;

(2) $q = 0$, $q = 1$ or $p = \frac{\delta_S}{\Delta S + \delta_S}$, $\frac{dq}{dt} = 0$, namely selecting cooperation strategy for supplier is stable.

The stable points of the system (127.16) are: (0, 0), (0, 1), (1, 0), (1, 1), $\left(\frac{\delta_S}{\Delta S + \delta_S - \delta_R}, \frac{\delta_H}{\delta_H + \Delta H - \delta_S}\right)$.

For double groups' evolutionary game, evolution equilibrium is equivalent to evolutionarily stable strategy (ESS). In the power system, a stable point is a local asymptotically stable point when satisfied det $(\psi) = 0$, tr $(\psi) = 0$, namely the stable strategy of evolutionary game.

The Jacobian matrix for System (127.16):

$$\Psi = \begin{bmatrix} \frac{\partial \tilde{p}}{p} & \frac{\partial \tilde{p}}{q} \\ \frac{\partial \tilde{q}}{p} & \frac{\partial \tilde{q}}{q} \end{bmatrix} = \begin{bmatrix} (1-2p)[-q\Delta H + (1-q)\delta_H] & p(1-p)(-\Delta H - \delta_H) \\ q(1-q)(\Delta S + \delta_S) & (1-2q)[p\Delta S - (1-p)\delta_S] \end{bmatrix} \tag{127.17}$$

(1) The stable point (0, 0) is substituted into Jacobian matrix, we get

$$\Psi = (0,0) = \begin{bmatrix} \delta_H & 0 \\ 0 & -\delta_S \end{bmatrix} \tag{127.18}$$

The characteristic roots are $\lambda_1 = \delta_H$, $\lambda_2 = -\delta_S$. δ_H and δ_S are respectively the cost (interest) loss for one party because of the other party fail to provide adequate information to share after establishing the cooperation alliance, and relate to the degree of fully cooperation with each other. When deviation degree of is smaller for one party, there may be a negative value for the other party's loss comparing to not establish cooperation relationship with each other, this kind of situation indicate that cost of the participants are increased (interest decreased) comparing to completely cooperation, but are still decreased (interest increased) comparing to non cooperation. When the characteristic roots are all negative, the stable point for the evolutionary game is ESS; if the characteristic roost is a positive and a negative, the stable point is saddle points; if the characteristic roots are all positive, then the stable point is not the ESS of evolutionary game.

(2) The stable point (0, 1) is substituted into Jacobian matrix, we get

$$\Psi = (0,1) = \begin{bmatrix} -\Delta H + \delta_S & 0 \\ 0 & \delta_S \end{bmatrix} \tag{127.19}$$

The characteristic roots are $\lambda_1 = -\Delta H + \delta_S$, $\lambda_2 = \delta_S$.

(3) The stable point (1, 0) is substituted into Jacobian matrix, we get

$$\Psi = (1,0) = \begin{bmatrix} -\delta_H & 0 \\ 0 & \Delta S - \delta_H \end{bmatrix} \tag{127.20}$$

The characteristic roots are $\lambda_1 = -\delta_R$, $\lambda_2 = \Delta S - \delta_H$.

(4) The stable point (1, 1) is substituted into Jacobian matrix, we get

$$\Psi = (1,1) = \begin{bmatrix} \Delta H - \delta_S & 0 \\ 0 & \delta_H - \Delta S \end{bmatrix} \tag{127.21}$$

The characteristic roots are $\lambda_1 = \Delta H - \delta_S$, $\lambda_2 = \delta_H - \Delta S$.

The identifying method of stability for the points (0, 1), (1, 0), (1, 1) are the same with (127.1).

(5) The stable point $\left(\frac{\delta_S}{\Delta S+\delta_S-\delta_R}, \frac{\delta_H}{\delta_H+\Delta H-\delta_S}\right)$ is substituted into Jacobian matrix, we get

$$\Psi\left(\frac{\delta_S}{\Delta S + \delta_S - \delta_R}, \frac{\delta_H}{\delta_H + \Delta H - \delta_S}\right) = \begin{bmatrix} 0 & \frac{\delta_S(\Delta S-\delta_H)(\delta_H-\Delta R-\delta_H)}{(\Delta S+\delta_S)^2} \\ \frac{\delta_H(\Delta R-\delta_S)(\delta_S+\Delta S-\delta_R)}{(\Delta R+\delta_R)^2} & 0 \end{bmatrix} \tag{127.22}$$

The characteristic roots are

$$\lambda_1 = \sqrt{\frac{\delta_S\delta_H(\Delta S - \delta_H)(\Delta R - \delta_S)(\delta_H - \Delta R - \delta_H)(\delta_S + \Delta S - \delta_R)}{(\Delta R + \delta_R)(\Delta S + \delta_S)}}$$

$$\lambda_2 = -\sqrt{\frac{\delta_S\delta_H(\Delta S - \delta_H)(\Delta R - \delta_S)(\delta_H - \Delta R - \delta_H)(\delta_S + \Delta S - \delta_R)}{(\Delta R + \delta_R)(\Delta S + \delta_S)}}$$

The stable point is saddle point and not the evolution equilibrium.

127.3.3 Discussion

The dynamic phase evolution diagram of strategic alliance with different combination of two parameters are gave by Figs. 127.1, 127.2, 127.3, 127.4.

In Fig. 127.1, the parameters mean the strong position of hospital make suppliers suffer a bigger loss, at this time the stable point (0, 0) and (1, 1) of the evolutionary game are local asymptotic stability, namely the strategies (non cooperation, non cooperation) and (cooperation, cooperation) are the stable strategy of long-term evolution, only after long-term evolution, the system achieve

Fig. 127.1 The dynamic phase evolution diagram of strategic alliance when $\delta_H < 0$, $\delta_S > \Delta H > 0$

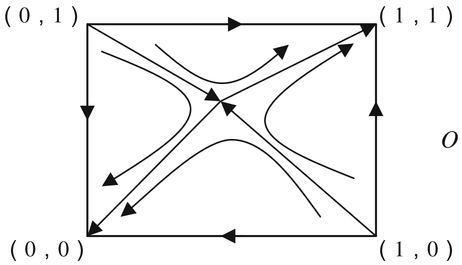


Fig. 127.2 The dynamic phase evolution diagram of strategic alliance when $\delta_H > 0$, $\delta_S > \Delta H > 0$

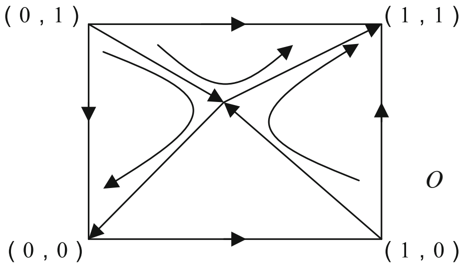


Fig. 127.3 The dynamic phase evolution diagram of strategic alliance when $\delta_H < 0$, $\delta_S < 0$

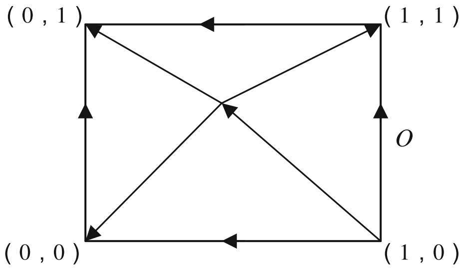
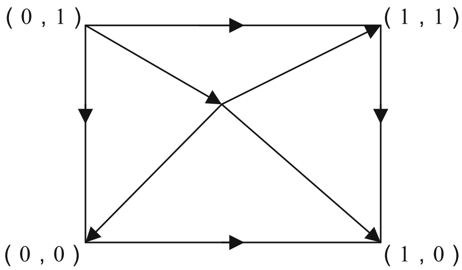


Fig. 127.4 The dynamic phase evolution diagram of strategic alliance when $\Delta S > \delta_H > 0$, $\delta_S < 0$



to stable status; Fig. 127.2, only stable point (1, 1) is local asymptotic stability of the system, namely the strategy (cooperation, cooperation) is the stable strategy of long-term evolution, whether the system evolutes to steady state relate to the initial state; In Figs. 127.3, 127.4, (1, 0) (0, 1) are respectively local asymptotic stability for the system, namely the stable strategy are respectively points (cooperation, non cooperation) and (non cooperation, cooperation), whether the system evolutes to steady state relate to the initial state; Thereunto, the parameters in Fig. 127.3 mean that hospital (suppliers) will suffer a little loss when the partner appear moral risks, and still is profitable compared to without cooperation for both sides, even though there is a decrease in cost for the hospital, but both sides still accept the result of game. In Fig. 127.4, the parameters mean the hospital will suffer a bigger loss when suppliers conceal real prices of drugs, but the suppliers still control the initiative and the profit loss is less even though the hospital has a strong policy, the final game results for two sides are the hospital gets more favorable cost and suppliers have to sacrifice a portion of the profits to ensure the products marketing.

127.4 Conclusion

Above the analysis, we can conclude that, first, for hospital and suppliers to establish the strategic alliance, both sides should try hard to create more profits or save more costs to realize win-win; second, because the hospital has some advantages, it should consider to assign part of the interests with suppliers in order to inspire them to take part in the cooperation and share the information as far as possible. In the condition of incomplete information sharing, hospital and suppliers should cooperate actively with each other to reduce the unilateral loss and prompt the full cooperation in the long-term game process.

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Chapter 128
Review of Researches on Logistics Industry Clusters Sustainable Development

Ai-min Deng, Hong-fei Zhong, Hui-lin LI and Jie Wang

Abstract As a third profit source, logistics has attracted much attention and realized great leap development. A worldwide large stream of goods, which is the product of economic globalization, has given rise to serious environmental problems. Very often, a little increase in marginal cost can accomplish much reduction in emissions. The trade-offs between environment and costs can be balanced by sustainable cluster management. In this paper, we present a review that highlights the contribution of worldwide scholars to logistics industry clusters sustainable development, which involves interactive development of manufacturing and logistics industry clusters, clusters upgrading and ecological integration, as well as sustainable clusters management countermeasures. Moreover, further research directions are also proposed according to the existence shortcomings of logistics clusters.

Keywords Clusters ecological integration · Clusters upgrading · Interactive development · Logistics industry clusters · Management countermeasures · Sustainable development

128.1 Introduction

Logistics industry cluster, emerging as a producer service industry and a new industry mode, whose function and huge economic value are more and more obvious, has a great push to the economic development (Fan 2010). However, there are some problems in sustainable development of logistics industry clusters.

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Firstly, transport routes planned by logistics enterprises within clusters are not reasonable, have given rise to some irrational phenomenon, such as no-load running, convective transport, circuitous transportation, repetitive traffic, commodity shunting, excessively long-distance traffic, which cause fuels waste (Fang and Zhang 2008). Secondly, our logistics park vacancy rate is as high as 60 %, so that less gain rewarded. Last but not the least, not enough attention has been paid to green logistics, so global warming becomes a top environmental concern. As we know, hazardous, noise, waste, harmful chemical, which produced during transportation, distribution, warehousing and circulation processing, can cause environment pollution and even affect the health of human body. Sustainable cluster management, which doesn't sacrifice ecology as price, therefore, can help to balance this trade-offs and achieve sustainable development of logistics industry clusters, and also become the research focus.

Studies on the theory and practice of industrial clusters are systematic and comprehensive, but for logistics industry cluster researches, especially sustainable development of logistics industry clusters, are relatively lag behind. Worldwide scholars in the field of logistics industry clusters focus on the research of logistics parks and its investment evaluation, regional logistics, interaction between logistics parks and the region economy, logistics clusters' formation mechanism, development mechanism and pattern, competitiveness, informatization, etc. But now, sustainable development of logistics industry clusters has gained an increasing attention. The purpose of this overview is to review informed researches from the aspects of interactive development of manufacturing and logistics industry clusters, clusters upgrading and ecological integration, as well as sustainable clusters management countermeasures, then propose further exploration topics to facilitate logistics industry cluster accomplish sustainable development.

This article proceeds as follows: we present worldwide relevant research dynamics in Sect. 128.2, which includes three parts, sustainable clusters management countermeasures in Sect. 128.3, conclusions and the prospect of research in Sect. 128.4.

128.2 Research Dynamics

128.2.1 Interactive Development

On account of our current industrial structure, the main driving force for logistics industry development is manufacturing, although manufacturing dependence on logistics industry is less than that of services (Su and Zhang 2011). Interactive development of manufacturing and logistics industry clusters, therefore, is of significance mean to promote structure adjustment and industrial upgrading of both industry clusters.

Chen and Jin (2007) analyzed the symbiotic mutual and benefit relationship between manufacturing clusters and logistics services through the biology Logistic model, and conclusion is that the reliance logistics industry depends on manufacturing industry is beyond the reliance the manufacturing industry on logistics industry, that is, with the industrial cluster into boom deepening stage, the contribution logistics services to manufacturing enterprise become much more larger, eventually each other's contribution will differ not quite, to achieve the ultimate equilibrium state, and maximize the emergence effect of complex cluster system (Chen and Jin 2007). Xu et al. (2007) discussed the synergic development relationship between manufacturing industry cluster and logistics services through the Shaoxing textile cluster's case, demonstrated that the synergic development can improve both their production efficiency and profits, so as to enhance the overall competitiveness of the whole area economy (Xu et al. 2007).

The quantitative assessment of coordination between logistics industry and manufacturing in Jiangsu province by Zhao (2010) with the method of DEA, and the status of their coordinated development was also discussed, and the green supply chain management strategy was put forward (Zhao 2010). Li and Zhao (2010) thought linkage development of manufacturing and logistics industry is the necessary approaches to promote the transformation upgrading of manufacturing, and put forward the city logistics industry and manufacturing clusters of linkage development with the Taiwan mode and purchasing trade and logistics integration mode in the light of the characteristics of Ningbo manufacturing clusters, and analyzed the feasibility of these two models (Li and Zhao 2010).

Xiao (2011) analyzed current situation and looked inside the main sticking point of interactive development of manufacturing and logistics industry, gave linkage development path as well (Xiao 2011). Wu (2011a, b) discussed the linkage mode with the symbiosis theory, and put forward specific strategies for interactive development of manufacturing and logistics industry (Wu 2011a).

Logistics and manufacturing industry are mutual development and restrict with each other. They are long-term equilibrium relationships (Wu 2011b). All in all, in order to promote their all-around interactive development and clusters upgrading, awareness of the interactive development should be established, the overall service capacity of logistics industry should be enhanced, the manufacturing logistics planning and management should be strengthened, a scientific mechanism for their interactive development should be set up.

128.2.2 Clusters Upgrading

The developed countries practice show that hoisting capability of logistics enterprises is the vital way to realize logistics industry upgrading. Under the global value chain, aiming at logistics resource integration on the basis of logistics operation competence, our logistics enterprises should select a specific and applicable upgrading path, and set different upgrading goals in line with different types of global value chain to build a modularization logistics cluster are effective tactics choice for our logistics industry clusters upgrading (Sloan 1996).

Song (2011) combined logistics with auto industry, studied power and process of the enterprise logistics industry clusters, put forward countermeasures to update the logistics industry cluster, hold that innovation and learning can facilitate automobile logistics industry cluster upgrade (Song 2011). Wang (2008) pointed out that the utilization of foreign direct investment to our logistics industry cluster has not only a direct impetus to the upgrading of the industrial structure, also indirectly to drive the technology progress of the industry, management modernization and competition, and efficiency of the related industry, and put forward the countermeasures to attract FDI (Wang 2008). Song (2011) thought the global value chain and automobile logistics cluster pattern of development of coupling existed differences due to automobile logistics industry cluster evolution conditions and involves the regional different, so according to the global value chain and the development of logistics characteristics, there are three coupling model: local coupling model, regional coupling model and global coupling model (Song 2011). Zhang studied logistics enterprise cluster function upgrade on the based of industrial chain, and pointed out problems that should be solved in ascension logistics enterprise cluster function (Zhang 2006).

Tang (2009) systematically analyzed the integration mode and problems of the logistics industry cluster logistics chain, hold that the upgrade of logistics industrial clusters not only need to integrate localization logistics chain, and at the same time, regional integration, and global logistics chain integration is also the key factor; finally the author put forward the ideas and upgrade paths from the perspective of logistics chain integration: firstly is to promote large and small and medium-sized logistics enterprise logistics enterprise to establish a symbiotic logistics system that logistics chain is the core, and benign interaction with each other; secondly is to improve logistics industry cluster system environment construction to provide good system culture environment protection for the regional logistics chain integration; thirdly is to Strengthen the contact and cooperation to construct the new equality logistics cooperation network; last but not the least Four is to strengthen and global dialogue, and participate in the global logistics standardization formulation (Tang 2009). Song analyzed the effect of global value chain on the development of logistics industry in China and proposed the upgrade path and upgrade strategy in the background of the global value chain (Sloan 1996). Fan (2010) studied the upgrade of resource sharing type of logistics industry clusters located in the reform region, from the following three parts: upgrading drive mechanism, upgrade environment, upgrade mode; analyzed the upgrade the dynamic mechanism from both the external power and the internal power; analyzed the key upgrade factor of the resource sharing logistics industry cluster through the principal component analysis, from the two dimensions of macro and micro, comparative analysis was conducted between Wuhan city circle and Chang-Zhu-Tan urban agglomeration logistics industry clusters; finally, through the analysis of upgrade conditions and model choice of resource sharing logistics industry cluster, put forward that there are three ways in upgrading for the resources sharing of logistics industry cluster: the government organization and coordination, good environment and strengthen cooperation and technical innovation (Fan 2010).

Etienne (2009) made sure that FDI can promote industrial cluster is proposed, then put forward that the upgrade of industry cluster is also attract FDI drive the engine, and think of the industry agglomeration and industrial cluster is the way to attract FDI policies of the key factors (Etienne 2009). Azadegan and Wagner through the path analysis of industrial clusters innovation performance of 353 manufacturers to explore the influence of the enterprise, the conclusion was that enterprises can upgrade from the lower stage of production and design to that of a higher stage (Arash and Wagner 2010).

128.2.3 Ecological Integration

The concept of ecological community initially introduced into industrial ecology research can be date back to 1870s. In 1989, the concept of industry ecosystem was put forward at the first time by Frosch and Gallopoulos (1989), which became the ecological research beginning of industry clusters.

Ecological idea of Industry cluster comes from ecological industry, the core idea is to construct the material energy circulation system within industry clusters. Through the constantly recycling of material energy, so as to make full use of resources, eliminate environmental damage, realize escalating and sustainable development of the industry clusters, which reflects a kind of relationship repositioning between economic and social development, as well as a reconsidering and change to traditional non-sustainable industrialization pattern (Chen 2006). The existing literatures showed that ecological integration for industry clusters is of importance ways to realize the sustainable development of industry clusters (Yuan et al. 2004).

Under the circumstances of global resources crisis and increasingly serious pollution, ecological development of logistics industry clusters becomes top concern. At present, Studies mainly concentrate on ecological development of logistics parks, such as ecological logistic park's theoretical basis and concept, the types, characteristics, function and the development localization, the influence factors of formation and development, development mode, operation management and profit model, the ecology evolution analysis, and biological community of similarities and difference between enterprises, the ecological relationship analysis, niche differentiation competition strategy research, ecological evaluation, etc. (Wallner 1999; Wu and Wu 2009).

In addition, the internet of things (IoT) enabling things connects thins, is very hot and provides technical support and development opportunities to our growing transportation and logistics industry. While ITS (intelligent transportation system) under IoT can make the urban road traffic capacity increase 2–3 times, can make the traffic congestion decreased by 20–80 %, 30 % fewer parking, driving time reduced by 13–45 %, 30 % less fuel cost, emissions reduced by 26 %, and the number of traffic accidents will be multiplied reduce, effectively improve the transportation efficiency, which will produce huge economic and social efficiency (Deng et al. 2012).

In sum, in the perspective of IoT with industry cluster, ecology, systematic and other multiple crossed theory to research on sustainable clusters management of logistics industry clusters worth our further exploring.

128.3 Sustainable Clusters Management Countermeasures

Common problems existed in our logistics industry clusters are: lack of cooperation and coordination, strong homogeneous, core business not outstanding, low degree of symbiosis, logistics information construction is backward; the speed of logistics network development is slow. Although for the healthy development of the logistics industry, government has issued a series of policies, but management countermeasures for logistics clusters are still lacking.

It's know to us all that government plays a strategic role in facilitating the emergency and development of an industrial cluster, as well as improving the performance of each key industrial cluster, so does logistics industry cluster. Once clusters have been formed, a comprehensive set of facilitating policies, from information provision and networking to tax codes and labor laws, are necessary. Carlsson and Mudambi found that one of the primary challenges for policy makers is to create a favorable climate for private entrepreneurship, often related to the formation of clusters. British scholar Jay Mitra sorted clusters policies commonly used by European and American countries since the late twentieth century, based on the investigation to small and medium-sized enterprise cluster in Europe in 2001 (Table 128.1) (Jay 2003).

Table 128.1 Commonly cluster polices in European and American countries

Policy types	Policy content
Enterprise orientation	For enterprise to provide financing, development consulting services, training talents, etc
Enhance clusters attraction	Encouraging internal investment to attract economic resources of outside technology, capital and labor
Build Service facilities	Strengthening the construction of physical facilities, knowledge, special services and technology center
Information management	Facilitating information collection, storage, circulation and trade of technology, market, export and business
Training, research and development	Supporting projects of education, training, R&D
Encourage cooperation	Supporting enterprise network and synergy, fostering open competition and the cultural atmosphere

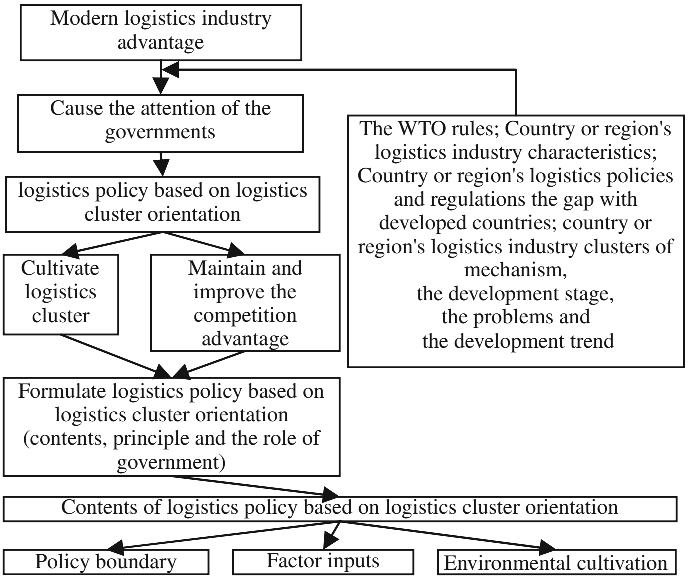

Fig. 128.1 Logistics policy theory model based on logistics cluster orientation

Su (2007) focused on the analysis of support measures taken by local government during the forming stage of industry cluster, with the combination of the government's policy framework in the development of the logistics industry cluster according the characteristics of the forming stage of industry cluster (Su 2007).

Yang (2008) constructed the logistics policy theoretical framework of industry cluster for Beijing city according to the logistics policy aim, policy design principles, and the implementation way on the basis of industry cluster theory (Fig. 128.1) (Yang 2008).

128.4 Conclusion

In summary, mainly related researches of logistics clusters made by domestic and foreign scholars are formation mechanism, competition, upgrading, innovation, synergic development with other industrial clusters. Further research directions, therefore, can be explored from the following four respects: (1) Attach importance to research on sustainable clusters management of logistics industry clusters in the perspective of IoT with industry cluster, ecology, systematic and other multiple crossed theory; (2) conducting more studies on logistics clusters from the aspect of the global value chain; (3) emphasis on researching linkage development between logistics clusters and manufacturing, and even other industry clusters; (4) discussing innovation and upgrading of logistics industry clusters positively to achieve sustainable and healthy development.

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Chapter 129
Study on Supply Chain Management Model with the Perspective of Revenue Sharing

Rong-fu Zhou and Chao-bo Zhu

Abstract Reasonable revenue sharing among supply chain partners is one of the key factors for SCM. From a perspective of revenue sharing, this paper makes comparative analysis and calculations on revenue sharing coefficient, net interest and relevant effort level among supply chain partners under their diffident action strategies according to game theory, and a moderate centralized control model was proposed after calculating.

Keywords Effort level · Nash equilibrium · Revenue sharing · Supply chain

129.1 Introduction

Revenue sharing among supply chain partners directly affects the supply chain collaboration (Nagurney 2010), so that how to reasonably distribute interest in supply chain has been extensively investigated by domestic and foreign scholars, who have already established several distribution model, such as Shapley value method (Ma and Wang 2006; Zhang et al. 2009), simplified MCRS (Ye and Hu 2004; Jaber and Osman 2006), colony bar center model (Ma 2008; Wei and Choi 2010), Nash bargaining model (Liu 2009; Wang and Feng 2008). All those models require to forecasting the future interest as part of hypothesis premise and determining proper distribution ratios, referring to factors that affect revenue sharing among supply chain partners (contribution degree, location, effort level of partners

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and risk, etc.). However, it's difficult to estimate the cost and revenue of partners in different cooperation status and the objective functions structured by those distribution methods lack diversification in the fair principle which is hardly accepted by supply chain partners. All the defects limit models' application. Therefore, foreign scholars shift to study the ways of increasing the overall revenue of supply chain by scientifically designing the supply chain structure and SCM, rather than just simply sharing the revenue.

Giannoccaro and Pontrandolfo proposed a contract model to coordinate a three-stage (manufacturer-distributor-retailor) supply chain. The system efficiency can be achieved and the profits of all the SC actors can be improved by turning the contract parameters (Giannoccaro and Pontrandolfo 2004, 2009). Nicola Bellantuono et al. presented a model in which the supply chain partners participate in two different programs: (1) the supplier and the retailer enter a revenue sharing (RS) contract; and (2) the retailer offers an advance booking discount (ABD) program to the customers. They examined the conditions under which the benefit of the joint adoption of RS and ABD programs was higher than the sum of the benefits associated with separate adoptions of these two programs (Bellantuono et al. 2009). Satyaveer et al. presented a provider–retailer partnership model based on profit sharing. They proposed an approach to maximize the combined profit and sharing the profit among partners proportional to their risk (Chauhan and Proth 2005). Zuo-Jun presented a profit-maximizing supply chain design model in which a company has flexibility in determining which customers to serve and how much customers should pay for (Shen 2006); Salem proposed a framework and methodology for profit-sharing and transfer-pricing between network companies (Lakhal 2006). Luis studied the coordination of actions and the allocation of profit in supply chains under decentralized control in which a single supplier supplies several retailers with goods for replenishment of stocks. They purposed a tailor-made revenue sharing method (Guardiola et al. 2007).

Based on game theory, this paper compares the overall revenue and partner's revenue of supply chain under different SCM model (corporation and non-cooperation) and discusses how to determine a proper distribution ratio in which partners can enhance their effort level, maximize their own revenue and at the same time increase the overall revenue of the supply chain.

The formation of supply chain is complex and dynamic and the partners are changing all the time. However, to simplify the discussion, we assume that all the partners are playing static game. Cooperation is a set of action strategy, under which partners pursue collective interest. In this situation, the management model is called centralized supply chain management. On the other hand, non-cooperation is a set of action strategy, under which partners pursue individual interest. In this situation, the management model is called decentralized supply chain management.

129.2 Supply Chain Revenue Sharing Model Based on Non-cooperation Action Strategy

129.2.1 Question Description and Modeling

To simplify the research, we assume that there is only one core enterprise, which is A and only one partner, which is B in the supply chain. Both A and B are rational and their attitude towards all factors that affect supply chain management is different. Because supply chain can't run without innovation activities, the cost of each partner comprises two parts: productive cost and innovative cost. For each task accomplished, productive cost can be calculated and measured, which is a relatively fixed constant that has nothing to do with effort level; however, innovative cost is related to effort level. The more effort a partner pay, the more innovative cost it takes and the growth rate accelerates. Here we set: C_{AO} and C_{BO} as the productive cost of enterprise A and B; C_{AX} and C_{BX} as innovative cost of enterprise A and B; β_A and β_B as the coefficient of innovative cost for the two enterprises; X_A and X_B as effort level; α_A and α_B as coefficient of contribution degree for the two enterprises; S and 1−S as distribution ratios of A and B; T as regular fee that A pays for B.

The net revenue of the supply chain is:

$$\begin{aligned} P = &\left[\frac{1}{2}(\alpha_A X_A + \alpha_B X_B)^2 + (\alpha_A X_A + \alpha_B X_B) + R_0\right] \\ &- \left[C_{AO} + \frac{1}{2}(\beta_A X_A)^2 + C_{AX} + C_{BO} + \frac{1}{2}(\beta_B X_B)^2 + C_{BX}\right] \end{aligned} \tag{129.1}$$

The net revenue of A and B are:

$$\begin{aligned} P_A = &S\left[\frac{1}{2}(\alpha_A X_A + \alpha_B X_B)^2 + (\alpha_A X_A + \alpha_B X_B) + R_0\right] \\ &- \left[C_{AO} + \frac{1}{2}(\beta_A X_A)^2 + C_{AX}\right] - T \end{aligned} \tag{129.2}$$

$$\begin{aligned} P_B = &(1-S)\left[\frac{1}{2}(\alpha_A X_A + \alpha_B X_B)^2 + (\alpha_A X_A + \alpha_B X_B) + R_0\right] \\ &- \left[C_{BO} + \frac{1}{2}(\beta_B X_B)^2 + C_{BX}\right] + T \end{aligned} \tag{129.3}$$

129.2.2 The Determination of Effort Level

Calculating the partial derivative of X_A, X_B:

$$\frac{\partial P_A}{\partial X_A} = S[\alpha_A(\alpha_A X_A + \alpha_B X_B) + \alpha_A] - \beta_A^2 X_A = 0 \tag{129.4}$$

$$\frac{\partial P_B}{\partial X_B} = (1-S)[\alpha_B(\alpha_A X_A + \alpha_B X_B) + \alpha_B] - \beta_B^2 X_B = 0 \tag{129.5}$$

It follows from (129.4) and (129.5), at Nash equilibrium, the effort level of A and B which are X_A^0 and X_B^0 is given by:

$$X_A^0 = \frac{S\alpha_A\beta_B^2}{\beta_A^2\beta_B^2 - S\alpha_A^2\beta_B^2 - (1-S)\alpha_B^2\beta_A^2} \tag{129.6}$$

$$X_B^0 = \frac{(1-S)\alpha_B\beta_A^2}{\beta_A^2\beta_B^2 - S\alpha_A^2\beta_B^2 - (1-S)\alpha_B^2\beta_A^2} \tag{129.7}$$

$$\frac{X_A^0}{X_B^0} = \frac{S}{1-S}\cdot\frac{\alpha_A}{\alpha_B}\cdot\frac{\beta_B^2}{\beta_A^2}$$

Thus, the effort paid by supply chain partners when pursuing maximized interest has a positive relationship to their distribution ratio and contribution degree coefficient; has a negative relationship to their innovation cost coefficient.

129.2.3 Determination for Optimal Distribution Coefficient

Optimal distribution ratio should be determined at first. It follows from (129.6) and (129.7), where X_A^0 and X_B^0 are the functions of S and P, the net revenue of supply chain, is the function of X_A^0 and X_B^0, thus, P is also the function of S. In order to assign a value to S that can maximize the net revenue P, the partial derivatives of P with respect to S should be calculated.

$$\frac{\partial P}{\partial S} = \frac{\partial P}{\partial X_A^0}\cdot\frac{\partial X_A^0}{\partial S} + \frac{\partial P}{\partial X_B^0}\cdot\frac{\partial X_B^0}{\partial S} \tag{129.8}$$

It following from (129.6) and (129.7), that

$$\frac{\partial X_A^0}{\partial S} = \frac{\partial_A\beta_A^2\left(\beta_A^2\beta_B^2 - \alpha_B^2\beta_A^2\right)}{\left[\left(\beta_A^2\beta_B^2 - \alpha_B^2\beta_A^2\right) + S\left(\alpha_B^2\beta_A^2 - \alpha_A^2\beta_B^2\right)\right]^2} \tag{129.9}$$

$$\frac{\partial X_B^0}{\partial S} = \frac{-\partial_B \beta_A^2 \left(\beta_A^2 \beta_B^2 - \alpha_A^2 \beta_B^2\right)}{\left[\left(\beta_A^2 \beta_B^2 - \alpha_B^2 \beta_A^2\right) + S\left(\alpha_B^2 \beta_A^2 - \alpha_A^2 \beta_B^2\right)\right]^2} \tag{129.10}$$

Following from (129.1), the partial derivatives of P with respect to X_A^0 and X_B^0:

$$\frac{\partial P}{\partial X_A^0} = \alpha_A \left(\alpha_A X_A^0 + \alpha_B X_B^0\right) + \alpha_A - \beta_A^2 X_A^0 \tag{129.11}$$

$$\frac{\partial P}{\partial X_B^0} = \alpha_B \left(\alpha_A X_A^0 + \alpha_B X_B^0\right) + \alpha_B - \beta_B^2 X_B^0 \tag{129.12}$$

Following from (129.4), (129.5) and (129.7):

$$\alpha_A \left(\alpha_A X_A^0 + \alpha_B X_B^0\right) + \alpha_A = \frac{\beta_A^2 X_A^0}{S}$$

$$\alpha_B \left(\alpha_A X_A^0 + \alpha_B X_B^0\right) + \alpha_B = \frac{\alpha_B \beta_A^2 X_A^0}{S \alpha_A}$$

Substituting the two results above into Eqs. (129.11) and (129.12), we get:

$$\frac{\partial P}{\partial X_A^0} = \frac{1-S}{S} \beta_A^2 X_A^0 \tag{129.13}$$

$$\frac{\partial P}{\partial X_B^0} = \frac{\alpha_B}{\alpha_A} \beta_A^2 X_A^0 \tag{129.14}$$

Substituting Eqs. (129.9), (129.10), (129.13) and (129.14) into (129.8), and let $\frac{\partial P}{\partial S} = 0$,

$$\frac{1-S}{S} \alpha_A \beta_B^2 \left(\beta_A^2 - \alpha_B^2 \beta_A^2\right) - \frac{\alpha_B^2 \beta_A^2}{\alpha_A} \left(\beta_A^2 \beta_B^2 - \alpha_A^2 \beta_A^2\right) = 0$$

$S^0$and $1 - S^0$ are given by:

$$S^0 = \frac{\alpha_A^2 \left(\beta_B^2 - \alpha_B^2\right)}{\alpha_A^2 \left(\beta_B^2 - \alpha_B^2\right) + \alpha_B^2 \left(\beta_A^2 - \alpha_A^2\right)} \tag{129.15}$$

$$1 - S^0 = \frac{\alpha_B^2 \left(\beta_A^2 - \alpha_A^2\right)}{\alpha_A^2 \left(\beta_B^2 - \alpha_B^2\right) + \alpha_B^2 \left(\beta_A^2 - \alpha_A^2\right)} \tag{129.16}$$

The calculation results show that in order to maximize the overall revenue of supply chain, the two partners can share revenue according to ratio S^0, which is also called optimal distribution coefficient, and ratio $1 - S^0$. Then, we study the influence to optimal distribution coefficient given by contribution coefficient and innovation cost coefficient.

Calculating the partial derivatives of S^0 with respect to α_A and α_B:

$$\frac{\partial S^0}{\partial \beta_A} = \frac{2\alpha_A\alpha_B\beta_A^2\left(\beta_B^2 - \alpha_B^2\right)}{\left[\alpha_A^2\left(\beta_B^2 - \alpha_B^2\right) + \alpha_B^2\left(\beta_A^2 - \alpha_A^2\right)\right]^2} > 0 \tag{129.17}$$

$$\frac{\partial S^0}{\partial \beta_B} = \frac{-2\beta_A\alpha_B^2\alpha_A^2\left(\beta_B^2 - \alpha_B^2\right)}{\left[\alpha_A^2\left(\beta_B^2 - \alpha_B^2\right) + \alpha_B^2\left(\beta_A^2 - \alpha_A^2\right)\right]^2} < 0 \tag{129.18}$$

$$\frac{\partial (1 - S^0)}{\partial \alpha_A} = \frac{2\alpha_B\alpha_A^2\beta_B^2\left(\beta_A^2 - \alpha_A^2\right)}{\left[\alpha_A^2\left(\beta_B^2 - \alpha_B^2\right) + \alpha_B^2\left(\beta_A^2 - \alpha_A^2\right)\right]^2} > 0 \tag{129.19}$$

$$\frac{\partial (1 - S^0)}{\partial \alpha_B} = \frac{-2\beta_B\alpha_A^2\alpha_B^2\left(\beta_A^2 - \alpha_A^2\right)}{\left[\alpha_A^2\left(\beta_B^2 - \alpha_B^2\right) + \alpha_B^2\left(\beta_A^2 - \alpha_A^2\right)\right]^2} < 0 \tag{129.20}$$

Equations (129.17) and (129.19) show that optimal revenue distribution ratio increases with the increase of contribution coefficient. Equations (129.18) and (129.20) show that optimal revenue distribution ratio decreases with the increase of innovation cost coefficient.

129.3 Supply Chain Revenue Sharing Model Based on Cooperation Action Strategy

Previously we analyzed each partner's effort level and optimal distribution coefficient at Nash equilibrium when they adopt non-cooperative action strategies to pursue maximized individual net revenue. Next, we research that what kinds of distribution strategies can motivate each partner to take cooperative action strategies to achieve collective revenue maximization so that both partners' and overall net revenue increase and each partner's optimal effort level achieve Pareto Optimality.

129.3.1 Modeling Improvement

According to (129.1), calculate the partial derivative of X_A, X_B, and let the equations equal to zero:

$$\begin{cases} \frac{\partial P}{\partial X_A} = [\alpha_A(\alpha_A X_B + \alpha_B X_B) + \alpha_A] - \beta_A^2 X_A = 0 \\ \frac{\partial P}{\partial X_B} = [\alpha_B(\alpha_A X_B + \alpha_B X_B) + \alpha_B] - \beta_B^2 X_B = 0 \end{cases} \tag{129.21}$$

We get:

$$X_A^* = \frac{\alpha_A \beta_B^2}{\beta_A^2\beta_B^2 - \alpha_A^2\beta_B^2 - \alpha_B^2\beta_A^2} \tag{129.22}$$

$$X_B^* = \frac{\alpha_B \beta_A^2}{\beta_A^2\beta_B^2 - \alpha_A^2\beta_B^2 - \alpha_B^2\beta_A^2} \tag{129.23}$$

Compare Eqs. (129.22) and (129.6), Eqs. (129.23) and (129.7), Where $0 \leq S \leq 1$,

We find that $X_A^* \geq X_A^0$ and $X_B^* \geq X_B^0$.

The calculation results show that the overall net revenue at Pareto equilibrium is greater than that at Nash equilibrium, namely that when adopting non-cooperative strategies, each partner's effort level and the overall net revenue of supply chain is less than that when adopting cooperative strategies. The reason for this result we think is that without centralized management in supply chain, each partner pursues individual revenue maximization, which harms the overall revenue of the supply chain.

129.3.2 Optimization Analysis of Revenue Sharing for Improved Model

Due to the bilateral effect motioned above, partner's net revenue is generated at Nash equilibrium.

$$\begin{aligned} P_A^0 = S^0\left(\frac{1}{2}\left(\alpha_A X_A^0 + \alpha_B X_B^0\right)^2 + \left(\alpha_A X_A^0 + \alpha_B X_B^0\right) + R_0\right) \\ - \left(C_{AO} + \frac{1}{2}\left(\beta_A X_A^0\right)^2 + C_{AX}\right) - T \end{aligned}$$

$$\begin{aligned} P_B^0 = \left(1 - S^0\right)\left(\frac{1}{2}\left(\alpha_A X_A^0 + \alpha_B X_B^0\right)^2 + \left(\alpha_A X_A^0 + \alpha_B X_B^0\right) + R_0\right) \\ - \left(C_{BO} + \frac{1}{2}\left(\beta_\mathrm{B} X_B^0\right)^2 + C_{BX}\right) + T \end{aligned}$$

Hence, the overall net revenue of the supply chain is generated at the point where partners' effort level are X_A^0 and X_B^0:

$$\begin{aligned} P\left(X_A^0, X_B^0\right) = \left[\frac{1}{2}\left(\alpha_A^0 X_A^0 + \alpha_B^0 X_B^0\right)^2 + \left(\alpha_A^0 X_A^0 + \alpha_B^0 X_B^0\right) + R_0\right] \\ - \left[C_{AO} + \frac{1}{2}\left(\beta_A X_A^0\right)^2 + C_{AX} + C_{BO} + \frac{1}{2}\left(\beta_B X_B^0\right)^2 + C_{BX}\right] \end{aligned}$$

For improved model, partners' individual revenue and overall revenue of the supply chain are generated at the point where partners' effort level is X_A^*, X_B^*:

$$P_A^* = S^0\left(\frac{1}{2}\left(\alpha_A X_A^* + \alpha_B X_B^*\right)^2 + \left(\alpha_A X_A^* + \alpha_B X_B^*\right) + R_0\right) - \left(C_{AO} + \frac{1}{2}\left(\beta_A X_A^*\right)^2 + C_{AX}\right) - T$$

$$P_B^* = \left(1 - S^0\right)\left(\frac{1}{2}\left(\alpha_A X_A^* + \alpha_B X_B^*\right)^2 + \left(\alpha_A X_A^* + \alpha_B X_B^*\right) + R_0\right) - \left(C_{BO} + \frac{1}{2}\left(\beta_\mathrm{B} X_B^*\right)^2 + C_{BX}\right) + T$$

$$P\left(X_A^*, X_B^*\right) = \left[\frac{1}{2}\left(\alpha_A X_A^* + \alpha_B^0 X_B^*\right)^2 + \left(\alpha_A X_A^* + \alpha_B X_B^*\right) + R_0\right] - \left[C_{AO} + \frac{1}{2}\left(\beta_A X_A^*\right)^2 + C_{AX} + C_{BO} + \frac{1}{2}\left(\beta_B X_B^*\right)^2 + C_{BX}\right]$$

Due to $X_A^* \geq X_A^0$ and $X_B^* \geq X_B^0$,

Hence, $P_A^* \geq P_A^0, P_B^* \geq P_B^0,\ P\left(X_A^*, X_B^*\right) \geq P\left(X_A^0, X_B^0\right)$.

The results show that both partners' individual revenue and overall revenue of the supply chain increase at the point where the effort level of partner A and B achieve Pareto efficiency.

129.4 Conclusion

This paper analyzes the overall revenue and individual revenue under cooperative and non-cooperative action strategies. By comparing revenue value generated in different situation, we make conclusions that cooperative strategies is better than non-cooperative strategies, no matter referring to overall revenue or individual revenue. Moderate centralized control is necessary in order to implement cooperative action strategies.

In this paper, theoretical analysis and examples testify are made for two-stage supply chain and we assume that both of these two partners are risk neutral, therefore the applications of our research is limited. So, further study should be made on partners' revenue under different supply chain model if the supply chain is multiple-stage and risk is considered.

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Chapter 130
Supply Chain Factors Determining Customer Satisfaction in Iron & Steel Companies in China

Xiao-ning Zhu, Qun Zhang and Jia-qin Yang

Abstract This paper describes an empirical study investigating the supply chain factors which have high influence on customer satisfaction in Iron & Steel companies in China. A questionnaire is designed for this study, and fisher's exact test is used to identify the main factors under the consideration of the features of the data collected. As a result, 8 factors regarding supply chain management are determined, and the Iron & Steel companies can improve customer satisfaction accordingly.

Keywords Supply chain · Customer satisfaction · Iron & Steel companies · Empirical study

130.1 Introduction

Iron & Steel (I&S) companies play a very important role in China economy development as one of the foundation industry, since the rapid economic growth in China, the demand of steel continues to increase. However, as expected, such a fast growth has also resulted in industry-wide issues. The labor productivity and the competitiveness of I&S industry in China are still relatively low comparing to their counterparts in the developed countries, In addition, the average profit of the I&S companies are very low comparing with the companies in other industries such as construction industry and logistics industry. Increasing competition and slow growth in the I&S industry have stimulated the I&S companies focused on retaining current customers and attracting new ones.

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Customer satisfaction is critical to any product or service company because customer satisfaction is a strong predictor of customer retention, customer loyalty and product repurchase. Obviously it is more difficult to attract a new customer than retain a current customer, so it is very necessary to study how to improve the customer satisfaction. Consequently, theorists are continuing to explore new models and methods that may unlock meaningful information about customer satisfaction. However, there has been little (if any) published research focus on the issue of the main factors determining customer satisfaction in I&S companies, which is the primary motivation of this research. The rest of this paper is organized as follows. The Sect. 130.2 introduced the related literature about customer satisfaction. Following is a brief introduction of fisher exact probability test used in this research. Section 130.4 describes an empirical study of identifying supply chain factors determining customer satisfaction in I&S companies in China. The primary data for this research are collected from 30 I&S companies in China. Finally, main supply chain factors to improve the customer satisfaction for I&S companies are identified and discussed based on the results in Sect. 130.5.

130.2 Literature Review

Satisfaction is a person's feelings of pleasure or disappointment resulting from comparing a product's perceived performance (or outcome) in relation to his or her expectations (Gupta 2004). If the performance falls short of expectations the customer is dissatisfied. If the performance matches the expectations the customer is satisfied. If the performance exceeds the expectations the customer is highly satisfied or delighted. Hansemark and Albinsson (2004) state that "satisfaction is an overall customer attitude towards a service provider, or an emotional reaction to the difference between what customer anticipate and what they receive, regarding the fulfillment of some need, goal or desire".

Under the recognition that customer satisfaction is a central construct in marketing research (Yongju and Yongsung 2010; Hess et al. 2003; Jiannan et al. 2006), the next important issue is the factors affect the customer satisfaction. It can be observed from the recent literature that many scholars focus on this issue. Krishnan and Hari (2009) study the factors determining customer satisfaction in consumer durable white goods in Chennai, Tamilnadu. The results show that fourteen factors extracted from the analysis. Sureschandar et al. (2002) present a study which investigate the relationship between service quality and customer satisfaction. Ahmad et al. (2012) propose a rule-based method that can be used to identifying the factor structure in customer satisfaction. The proposed method can be used for both types of features: ordinal and categorical. The proposed method is more efficient than previously recommended methods.

More scholars insist that after-sales service is a part of customer relationship management (CRM) helps to enhance a customer's loyalty, so Shaharudin et al. (2009) study the factors affecting customer satisfaction in after-sales service of

Malaysian electronic business market. A sample of 358 Spanish customers that had carried out their purchase in different types of grocery stores (in particular, hypermarkets and supermarkets) has been analyzed to identify the customer satisfaction's key factors in Spanish grocery stores (Martínez-Ruiz et al. 2010). Some of the research focus on the factors most affected satisfied customers in the restaurant business (Jinsoo and Zhao 2010; Yen-Soon et al. 2004; Goodson et al. 2002). Jeewon et al. (2008) identifies factors to influence customer satisfaction (m-satisfaction) and loyalty (m-loyalty) in m-commerce by empirically-based case study.

130.3 Methodology

130.3.1 Questionnaire Design

A questionnaire is designed to collect all necessary data from the I&S companies. There are five sections in this questionnaire: (1) basic information of these I&S companies, (2) supply chain collaborative products design and development information in I&S companies, (3) supply chain collaborative procurement in I&S companies, (4) supply chain collaborative manufacturing in I&S companies and (5) supply chain collaborative selling in I&S companies.

130.3.2 Descriptive Statistical Analysis

Descriptive statistical analysis is used to describe the main features of the data collected from the questionnaire. Simple summaries (frequency, mean value, standard deviation and variance) of each variable are provided in this research.

130.3.3 Fisher's Exact Test

The counts of profiles in each category are made and inserted into a 2*2 contingency table. The most generally applicable statistical test is Fisher's exact test (Fisher 1922). This test is suitable for data generated by classifying objects in two different ways and is suitable for analysis when some of the frequencies are low and use of the Chi squared test is ruled out (e.g. some expected values are 0 or less than 20 % are less than 5).

130.4 Results Discussion

The primary data for this study were collected from 30 I&S companies through the questionnaire survey. Stratified sampling method is used to ensure the representative of the data. Four companies are selected from the large I&S companies (the number of employees above 100000), twelve medium-sized I&S companies (the number of employees between 50000 and 100000) and 14 small I&S companies (the number of employees below 50000) are identified.

130.4.1 Questionnaire Design Result

As mentioned before, there are five sections in the questionnaire regarding the supply chain factors determining the customer satisfaction in I&S companies. The detail content is shown in Table 130.1.

As shown in Table 130.1, there are 27 categories related with the supply chain management. For example, in order to invest the communications of sale Dep. and other Dep., the question is designed as follows:

How often the sale Dep. and other Dep. communicate? (Read each one as if it referred to your company)

Dep.	Daily	Weekly	Monthly	Quarterly
R&D				
Purchase				
Manufacturing				

In order to invest the information sharing situation, the question is designed as follows:

What information do your company share with your suppliers? (Read each one as if it referred to your company)

- No share information
- Share order information
- Share inventory information
- Share manufacturing information.

130.4.2 Internal Consistency Test

In statistics and research, internal consistency is typically a measure based on the correlations between different items on the same test (or the same subscale on a larger test). It measures whether several items that propose to measure the same general construct produce similar scores. Cronbach's α is used to measure the

Table 130.1 27 categories related with the supply chain management

Section	Category
Basic information	Size
	Profit
	Nature
	Organization structure
	N. of levels
	Information technology
Supply chain collaborative products design and development	Average response time of orders
	Communications of R&D Dep. and other Dep.
	Supplier involve in product development
	Distributor involve in product development
	Customer involve in product development
Supply chain collaborative procurement	Coal qualified rate
	Iron ore qualified rate
	Raw material inventory
	On time delivery
	N. of main suppliers
	Information sharing with suppliers
	Suppliers retention rate
	Joint managed inventory
Supply chain collaborative manufacturing	Production-demand rate
	Outsourcing rate
Supply chain collaborative selling	Production-sale rate
	Communications of sale Dep. and R&D Dep.
	Communications of sale Dep. and purchase Dep.
	Communications of sale Dep. and manufacturing Dep.
	Period of returns
	Distributor retention rate
	Customer satisfaction

internal consistency of the data in this research. It was first named alpha by Lee Cronbach in 1951, and it is widely used in the social sciences, business, nursing and other disciplines.

Cronbach's α is defined as:

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum S_{\mathrm{i}}^2}{S_T^2}\right) \tag{130.1}$$

where K is the number of the components (K-items), S_T^2 is the variance of the observed total test scores, and S_{i}^2 is the variance of component i for the current samples.

The Cronbach's α is 0.6220 in this research which means that the internal consistency is acceptable.

Table 130.2 Range, mean and variance of the basic information of the 30 I&S companies

Category	Range	Mean	Variance
Profit	6	3.57	1.892
Size	3	6.50	0.064
Nature	1	0.77	0.128
Organizational structure	4	6.93	1.873
No. of levels	2	4.20	0.344
Information technology	4	6.93	1.461

130.4.3 Summary of the Questionnaire

The data from the questionnaire in terms of basic information is summarized in Tables 130.2 and 130.3. As shown in Table 130.2, the variance of information technology is 1.461, which means that the gap of applying the information technology should be get highly noticed. One of the 30 I&S companies does have the website of its own company, and most of the private companies are not satisfied with the applying of the information technology. As is shown it Table 130.3, 76.7 % (23 out of 30) of the companies taking part in this research is state-owned company, and most of the I&S companies (63.3 %) are functional organizational structure, which can offer high level of specialization and efficiency, however, pose a challenge for top management to maintain control as the organization expands. As organizations get larger and top management needs to delegate more decision-making responsibilities to each functional area, the degree of autonomy may also increase, making coordination of activities more difficult.

The summaries of the rest four sections are not listed in this research considering the limit of the pages.

130.4.4 Fisher's Exact Test Result

As mentioned before, there are 27 factors need to be tested by fisher's exact test. Profit is taken for example to show the fisher's exact test, and the first two hypotheses to be tested in this research are:

Hypothesis-1(a): Profit has a significant influence on customer satisfaction.

Hypothesis-1(b): Profit has a lower influence on customer satisfaction ($\alpha = 0.05$).

The results of the fisher's exact test are shown in Tables 130.4 and 130.5, the crosstabulation of profit and customer satisfaction is shown in Table 130.4.

As shown in Table 130.5, the value of fisher's exact test is 19.555, exact sig.(2-sided) is 0.066, greater than 0.05, therefore hypothesis-1(a)is refused with significant level of 5 %, which means that profit has a lower influence on customer satisfaction.

Table 130.3 Summary of the basic information of the 30 I&S companies

Category	Ranking	Number	Frequency (%)
Profit (million)	0.1–0.2	11	36.7
	0.2–0.5	6	20.0
	0.5–1	7	23.3
	>1	6	20.0
Total		30	100.0
Size (people)	10000–20000	5	16.7
	20000–50000	9	30.0
	50000–100000	12	40.0
	>100000	4	13.3
Total		30	100.0
Nature	Private	7	23.3
	State-owned	23	76.7
Total		30	100.0
Organizational structure	Hybrid	7	23.3
	Functional	19	63.3
	Others	4	13.3
Total		30	100.0
N. of levels	3	5	16.7
	4	14	46.7
	5	11	36.7
Total		30	100.0
Information technology	Poor	3	10.0
	Acceptable	10	33.3
	Good	17	56.7
Total		30	100.0

Table 130.4 Profit * customer satisfaction crosstabulation

Count		Customer satisfaction						Total
		1.00	2.00	3.00	4.00	5.00	6.00	
Profit	5.00	0	0	0	3	1	1	5
	6.00	1	0	2	1	2	3	9
	7.00	0	1	5	2	4	0	12
	8.00	0	0	0	0	4	0	4
Total		1	1	7	6	11	4	30

Table 130.5 Profit * customer impact analysis

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Point Probability
Pearson chi square	23.192a	15	0.080	0.057	
Likelihood ratio	24.888	15	0.051	0.051	
Fisher's exact test	19.555			0.066	
Linear-by-linear association	0.056b	1	0.812	0.877	0.060
N of valid cases	30				

Table 130.6 Supply chain factors determining customer satisfaction

Category	Fisher's exact test value	Exact sig. (2-sided)
Size	15.040	0.023
Information technology	11.154	0.030
Supplier involve in product development	11.110	0.030
Coal qualified rate	18.680	0.015
Iron ore qualified rate	17.696	0.030
Outsourcing rate	13.929	0.007
Meet the demand rate	17.990	0.020
Period of returns	16.375	0.010

130.5 Conclusion

27 categories related with the supply chain management (Table 130.1) are tested by fisher's exact test, and the supply chain factors determining customer satisfaction are identified:

As shown in Table 130.6, there are 8 supply chain factors have significant influence on customer satisfaction. The I&S companies can improve the customer satisfaction accordingly.

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Chapter 131
System Dynamics Simulation of Pork Supply Chain from the Perspective of Government

Wan-zhao Liu and Chun-ping Wang

Abstract It is a pessimistic problem to pork quality safety for a long time in our country, and discussing the measures from the point of supply chain has become the hotspot. The paper constructs pork supply chain system dynamics model. Through the computer simulation, researched the consequence of government supervision in different environment. The results show that, from the government perspective, in general, the supervision degree from strong to weak should be retail enterprise, slaughtering enterprises, breeding enterprise. However, the supervision effect to speciality stores is not such as to the slaughtering enterprises. That is to say, government should take more supervision to upstream node when downstream node showing high quality level.

Keywords Government supervision · Pork safety · Supply chain · System dynamics

131.1 Introduction

China has the largest pork production and consumption in the world, and the production and consumption takes about half of global in recent years (Sun 2006). But the pork quality events happened frequently, for example PRRS (Porcine

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Reproductive and Respiratory Syndrome) in most regions of China in 2007, clenbuteral in 2011, etc. Not only influence people's health of body and mind, but also restricts the pork industry international competitiveness. All of people take more and more attention to pork product safety, also contains some scholars (Sun et al. 2009). Domestic and overseas scholars all agree that implementation supply chain management is an effective way to solve the quality safety problems of pork, protect the consumer body health and life safety (Sun 2011; Hvolby 2003; Lu et al. 2003).

In the existing research, scholars mainly research the relationship between the nodes, and discuss the government how to control every node (Chen and Luo 2003; Dai 2006; Chee 2004). They did not clearly put forward the relative influence degree of each node to pork safety, and did not research which nodes should be taken more supervision for government. In fact, it is a meaningful problem for government to discuss which node is more important.

This paper has two main objectives. One is constructing pork supply chain system dynamic model, and another is simulating the pork supply chain, then discusses which node should be taken more supervised.

The innovation of this paper is that from the view of system discuss the role of node in pork supply chain. Provide a clear path for government to solve the problems of pork quality.

131.2 Construct System Dynamic Model

In this paper, the scope of pork supply chain defined that it only contains breeding enterprises, slaughtering enterprises, retail enterprises and government. The three nodes and government supervision constitute a system. Around the pork quality safety, each node in the system influences pork quality safety through some variables. According to relevant research (Deng and Yano 2006), this paper defined the variables which influence each node as follows. The main variable which influences pig-breeding enterprises is the scale of breeding (slaughter), and specific influence variables include quality level of feed, prevention and control level to epidemic and welfare level. The main variable which influences slaughtering enterprises is the capacity of slaughter, and specific influence variables include inspection level before slaughter, operation procedures during slaughter and inspection level after slaughter. The main variable which influences retail enterprises is the channel of sales (Farmers markets, supermarket, specialty store, etc.), and specific influence variables include the inspection level of pork inter retail enterprises, quality tracking and credit level (Mu-Chen Chen and Yen 2007). For government regulation, this paper researched it mainly from the view of punishing unsafety pork. According to the above, using vensim PLE software, establish pork system dynamics model as follows (Fig. 131.1), and the introduction of variables can be seen in Table 131.1.

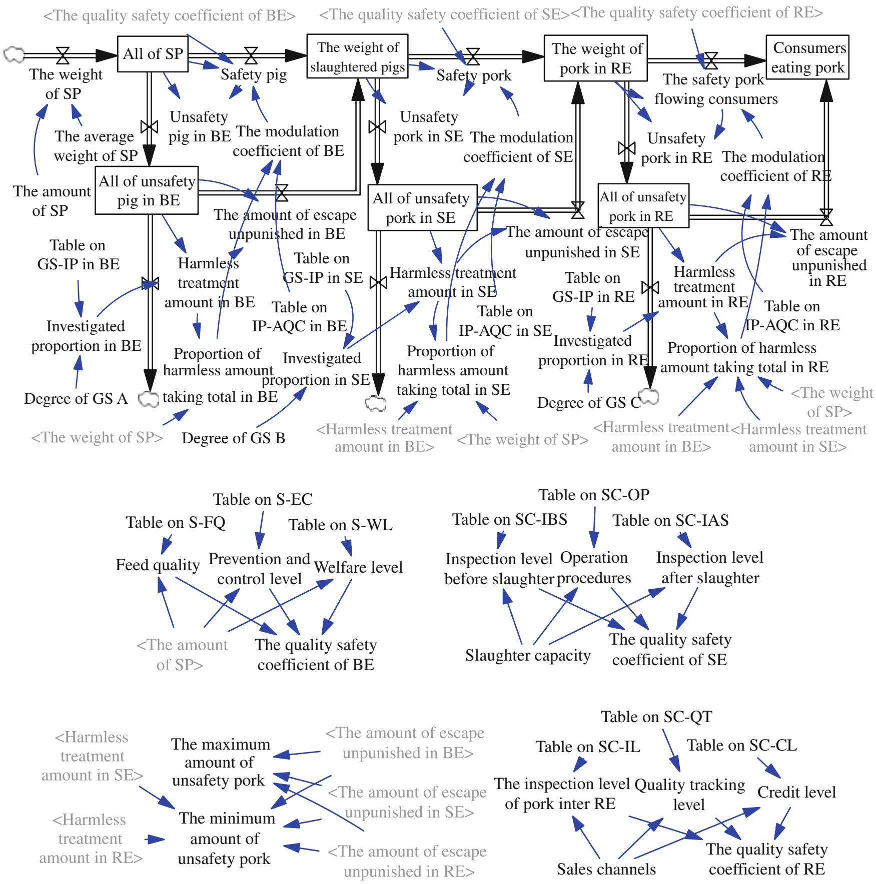

Fig. 131.1 The system dynamics model of pork supply chain

In fact, the model includes the following assumption. Firstly, breeding enterprise, slaughtering enterprises and retail enterprises are all in the completely competitive market. Only in this way, it can guarantee that the government supervision could carry out smoothly. Secondly, the weight of safety pig, the weight of safety pork and the safety pork flowing consumers are all relative concept. That is to say, every node probable contains unsafe pig (pork) which coming from upstream nodes. Thirdly, for breeding enterprise, slaughtering enterprises and retail enterprises speaking, when enterprise quality safety coefficient is less than the adjustment coefficient, the enterprise will be product according to adjustment coefficient.

Table 131.1 Introduction of variables in model

Variables	Abbreviation
The weight of slaughter pigs	The weight of SP
The amount of slaughter pigs	The amount of SP
The average weight of slaughter pig	The average weight of SP
All of slaughter pigs	All of SP
The weight of safety pig	Safety pig
Unsafety pig in breeding enterprises	Unsafety pig in BE
The quality safety coefficient of breeding enterprises	The quality safety coefficient of BE
The modulation coefficient of breeding enterprises	The modulation coefficient of BE
All of unsafety pig in breeding enterprises	All of unsafety pig in BE
Harmless treatment amount in breeding enterprises	Harmless treatment amount in BE
The amount of escape unpunished in breeding enterprises	The amount of escape unpunished in BE
Table on investigate proportion and adjust quality coefficient in breeding enterprises	Table on IP-AQC in BE
Proportion of harmless amount taking total in breeding enterprises	Proportion of harmless amount taking total in BE
Investigated proportion in breeding enterprise	Investigated proportion in BE
Table on government supervision and investigated proportion in breeding enterprises	Table on GS-IP in BE
Degree of Government supervision A	Degree of GS A
The weight of slaughtered pigs	
The weight of safety pork	Safety pork
Unsafety pork in slaughtering enterprises	Unsafety pork in SE
The modulation coefficient of slaughtering enterprises	The modulation coefficient of SE
All of unsafety pork in slaughtering enterprises	All of unsafety pork in SE
The amount of escape unpunished in slaughtering enterprises	The amount of escape unpunished in SE
Harmless treatment amount in slaughtering enterprises	Harmless treatment amount in SE
Table on investigate proportion and adjust quality coefficient in slaughtering enterprises	Table on IP-AQC in SE
Proportion of harmless amount taking total in slaughtering enterprises	Proportion of harmless amount taking total in SE
Investigated proportion in slaughtering enterprise	Investigated proportion in SE
Table on government supervision and investigated proportion in slaughtering enterprises	Table on GS-IP in SE
Degree of Government supervision B	Degree of GS B
The weight of pork in retail enterprises	The weight of pork in RE
The safety pork flowing consumers	The safety pork flowing consumers
Unsafety pork in retail enterprises	Unsafety pork in RE
The modulation coefficient of retail enterprises	The modulation coefficient of RE
All of unsafety pork in retail enterprises	All of unsafety pork in RE

(continued)

Table 131.1 (continued)

Variables	Abbreviation
The amount of escape unpunished in retail enterprises	The amount of escape unpunished in RE
Harmless treatment amount in retail enterprises	Harmless treatment amount in RE
Table on investigate proportion and adjust quality coefficient in retail enterprises	Table on IP-AQC in RE
Proportion of harmless amount taking total in retail enterprises	Proportion of harmless amount taking total in RE
Investigated proportion in retail enterprise	Investigated proportion in RE
Table on government supervision and investigated proportion in retail enterprises	Table on GS-IP in RE
Degree of Government supervision C	Degree of GS C
The amount of consumers eating pork	Consumers eating pork
Quality level of feed	Feed quality
Prevention and control level to epidemic	Prevention and control level
Welfare level	Welfare level
Table on slaughter and feed quality	Table on S-FQ
Table on slaughter and epidemic control	Table on S-EC
Table on slaughter and welfare level	Table on S-WL
The quality safety coefficient of slaughter enterprises	The quality safety coefficient of SE
Inspection level before slaughter	Inspection level before slaughter
Operation procedures during slaughter	Operation procedures
Inspection level after slaughter	Inspection level after slaughter
Slaughter capacity	Slaughter capacity
Table on slaughter capacity and inspection before slaughter	Table on SC-IBS
Table on slaughter capacity and operation procedures	Table on SC-OP
Table on slaughter capacity and inspection after slaughter	Table on SC-IAS
The quality safety coefficient of retail enterprises	The quality safety coefficient of RE
Sales channels	Sales channels
The inspection level of pork inter retail enterprises	The inspection level of pork inter RE
Quality tracking level	Quality tracking level
Credit level	Credit level
Table on sales channels and inspection level when inter retail enterprises	Table on SC-IL
Table on sales channels and quality tracking level	Table on SC-QT
Table on sales channels and credit level	Table on SC-CL
The maximum amount of unsafety pork flowing to consumers	The maximum amount of unsafety pork
The minimum amount of unsafety pork flowing to consumers	The minimum amount of unsafety pork

131.3 Parameters in the Model

131.3.1 Coefficient Assignment

There are three variables which need given the weight coefficient, the quality safety coefficient of BE, the quality safety coefficient of SE and the quality safety coefficient of RE. According to a large number of on-the-spot investigation, and combined with the expert's opinion, we give the weight coefficient as follows.

The quality safety coefficient of BE = Feed quality *0.45 + Prevention and control level *0.45 + Welfare level *0.1

The quality safety coefficient of SE = Inspection level before slaughter *0.3 + Operation procedures *0.4 + Inspection level after slaughter *0.3

The quality safety coefficient of RE = The inspection level of pork inter RE *0.35 + Credit level *0.2 + Quality tracking level *0.45

In order to express clearly, we give the equation about the maximum amount of unsafety pork and the minimum amount of unsafety pork.

The maximum amount of unsafety pork = The amount of escape unpunished in BE + The amount of escape unpunished in SE + The amount of escape unpunished in RE

The minimum amount of unsafety pork = IF THEN ELSE (IF THEN ELSE (The amount of escape unpunished in BE > Harmless treatment amount in SE, The amount of escape unpunished in BE − Harmless treatment amount in SE, 0) + The amount of escape unpunished in SE > Harmless treatment amount in RE, IF THEN ELSE (The amount of escape unpunished in BE > Harmless treatment amount in SE, The amount of escape unpunished in BE − Harmless treatment amount in SE, 0) + The amount of escape unpunished in SE − Harmless treatment amount in RE, 0) + The amount of escape unpunished in RE

131.3.2 Table Function Assignment

There are 15 table functions in the model. In order to determine the value more scientific, we surveyed 186 breeding enterprises, 173 slaughtering enterprises and 115 retail enterprises. At last, we determined the numerical of 15 table functions. (Tables 131.2, 131.3).

131.4 Results

According to the reality of our country, we assign values to some variables. Breeding scale, the amount of slaughter pigs = 1000 head/year. Slaughtering scale, 15 ten thousand head/years. Sales channel 1 = farmers markets, Sales

Table 131.2 Table functions

Channels and different variables	Corresponding numerical		
Sales channels	1	2	3
The inspection level of pork inter RE	0.9	0.98	1
Sales channels	1	2	3
Quality tracking level	0.25	0.8	0.98
Sales channels	1	2	3
Credit level	0.75	0.98	0.96

channel 2 = supermarket, Sales channel 3 = specialty store. And then, we used vensim PLE software simulate.

131.4.1 Simulation of Implement Different Supervision Degree to Breeding Enterprise and Slaughtering Enterprises

Setting of two state, state 1: Degree of GS A = 0.85, Degree of GS B = C = 0.8. State 2: Degree of GS B = 0.85, Degree of GS A = C = 0.8. Comparing the two states, observe the two variables, the maximum amount of unsafety pork, the minimum amount of unsafety pork. As shown in Fig. 131.2. We can see that, in state 2, the maximum amount of unsafety pork and the minimum amount of unsafety pork are all relatively lower. That is to say, in this states, government's supervision to slaughtering enterprises is better than to breeding enterprises (Fig. 131.3).

131.4.2 Simulation of Implement Different Supervision Degree to Slaughtering Enterprises and Supermarket

Selecting sales channels = 2, namely supermarket. Setting of two state, state 1: Degree of GS B = 0.85, Degree of GS A = C = 0.8; state 2: Degree of GS C = 0.85, Degree of GS A = B = 0.8. From Fig. 131.4, we can see that, in state 2, the maximum and the minimum amount of unsafety pork are all relatively lower. That is to say, in this state of supermarket, government's supervision to retail enterprises is better than to slaughtering enterprises.

Table 131.3 Table functions

Related variables	Corresponding numerical					
Proportion of harmless amount taking total in BE	0.00005	0.0001	0.0005	0.001	0.005	0.01
The modulation coefficient of BE	0.8	0.85	0.9	0.94	0.97	0.99
Proportion of harmless amount taking total in SE	0.0001	0.0005	0.001	0.005	0.01	0.015
The modulation coefficient of SE	0.8	0.85	0.9	0.95	0.97	0.99
Proportion of harmless amount taking total in RE	0.0001	0.00107	0.00275	0.005	0.007	0.01
The modulation coefficient of RE	0.8	0.86	0.9	0.94	0.97	0.99
Degree of GS A	0.5	0.6	0.7	0.8	0.9	1
Investigated proportion in BE	0.0005	0.001	0.005	0.01	0.05	0.1
Degree of GS B	0.5	0.6	0.7	0.8	0.9	1
Investigated proportion in SE	0.01	0.05	0.1	0.15	0.2	0.25
Degree of GS C	0.5	0.6	0.7	0.8	0.9	1
Investigated proportion in RE	0.001	0.005	0.014	0.033	0.054	0.1
The amount of SP	50	500	1000	2500	5000	10000
Feed quality	0.85	0.92	0.96	0.98	0.99	1
The amount of SP	50	500	1000	2500	5000	10000
Prevention and control level	0.8	0.9	0.95	0.96	0.97	0.99
The amount of SP	50	500	1000	2500	5000	10000
Welfare level	0.7	0.8	0.9	0.96	0.98	0.99
Slaughter capacity	1	2	10	20	50	100
Inspection level before slaughter	0.8	0.95	0.96	0.99	0.999	1
Slaughter capacity	1	2	10	20	50	100
Operation procedures	0.7	0.85	0.94	0.97	0.99	1
Slaughter capacity	1	2	10	20	50	100
Inspection level after slaughter	0.7	0.89	0.95	0.97	0.99	1

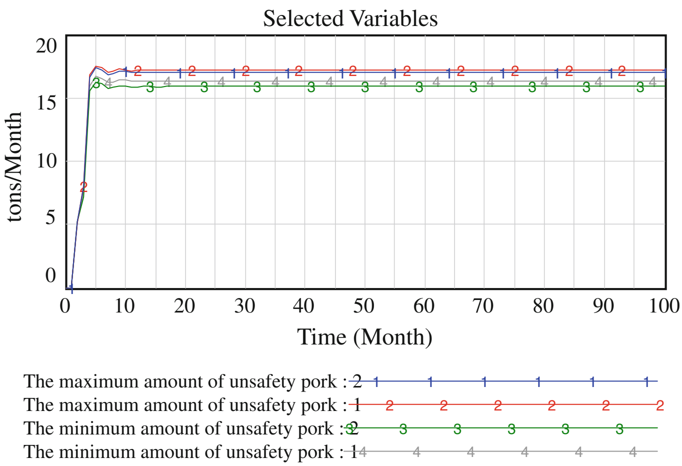

Fig. 131.2 Simulation to slaughtering enterprises and breeding enterprises

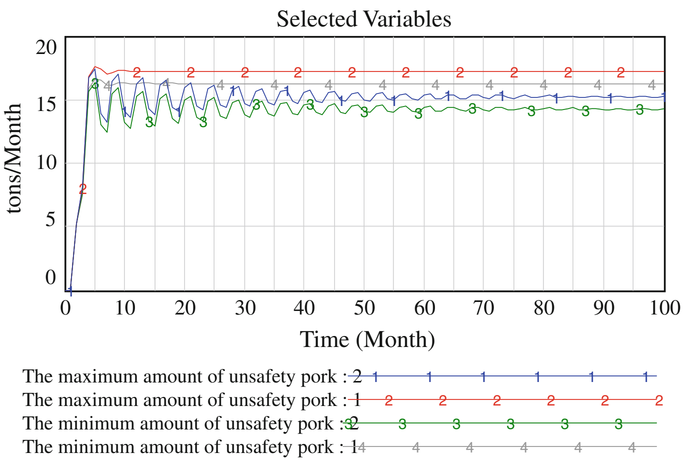

Fig. 131.3 Simulation to slaughtering enterprises and supermarket

131.4.3 Simulation of Implement Different Supervision Degree to Slaughtering Enterprises and Farmers Markets

Selecting sales channels = 1, namely supermarket. Setting of two state, state 1: Degree of GS B = 0.85, Degree of GS A = C = 0.8; state 2: Degree of GS C = 0.85, Degree of GS A = B = 0.8. From Fig. 131.4, we can see that, in state

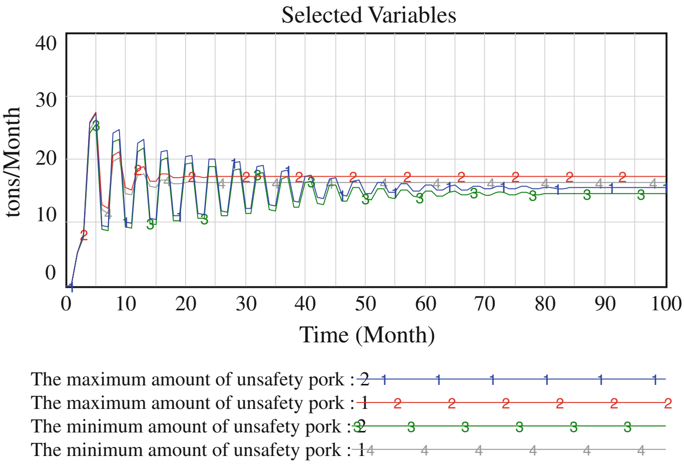

Fig. 131.4 Simulation to slaughtering enterprises and farmers markets

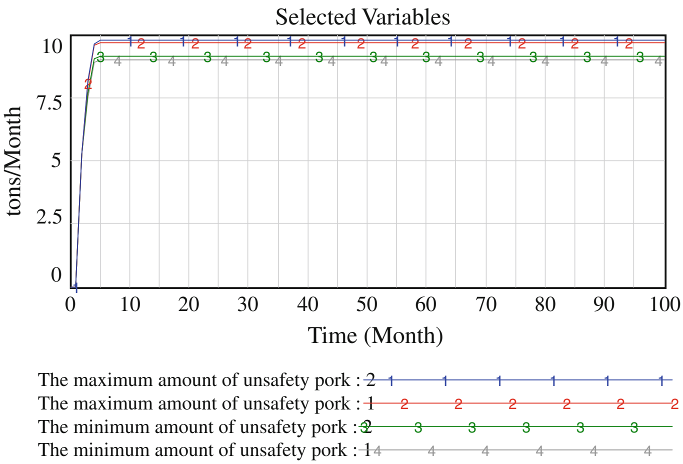

Fig. 131.5 Simulation to slaughtering enterprises and specialty store

2, the maximum and the minimum amount of unsafety pork are all relatively lower through intense volatility. That is to say, in this state of farmers markets, government's supervision to farmers markets is better than to slaughtering enterprises.

131.4.4 *Simulation of Implement Different Supervision Degree to Slaughtering Enterprises and Specialty Store*

Selecting sales channels = 3, namely specialty store. Setting of two state, state 1: Degree of GS B = 0.85, Degree of GS A = C = 0.8; state 2: Degree of GS C = 0.85, Degree of GS A = B = 0.8. From Fig. 131.5, we can see that, in state 1, the maximum and the minimum amount of unsafety pork are all relatively lower through intense volatility. That is to say, in this state of specialty store, government's supervision to slaughtering enterprises slaughtering enterprises is better than to retail enterprises.

131.5 Conclusion

In a given environment we can draw some conclusions. (1) In the general conditions, slaughtering enterprises made more significant influence of pork quality comparing with breeding enterprises. So government should take more supervision to slaughtering enterprises. (2) Compared with breeding enterprises, government should take more supervision to supermarket and farmers markets. However, government's supervision to specialty store was not better than to slaughtering enterprises. It's perhaps that specialty stores had higher self-discipline than other sales channel and government need not take strict supervision to them.

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Chapter 132
The Evaluation on the Regional Logistics Infrastructure Carrying Capacity Based on the Industrial Agglomeration Externalities

Chao Sun and Ming-fei Liu

Abstract Regional Logistics is an important guarantee for regional economic development. Logistics agglomeration externalities affect the formation of logistics infrastructure carrying capacity directly. The strength of the regional logistics infrastructure carrying capacity will be related to the regional logistics service performance directly. The key to enhance the basic carrying capacity of the logistics industry gathering area is to rationalize the spatial layout of the logistics cluster area. This article studies from the industrial agglomeration externalities, explores the influencing factors of the regional logistics infrastructure carrying capacity, and uses gray correlation analysis, factor analysis and cluster analysis methods. As an example of the scientific selection of the spatial layout of Hubei Province logistics gathering to discuss the comprehensive evaluation of the scientific reasonable position of regional logistics agglomeration area carrying capacity.

Keywords Cluster analysis · Factor analysis · Gray relational analysis · Logistics infrastructure carrying capacity · Regional logistics

132.1 Introduction

Since the 1980s, the logistics industry showing the accumulating phenomenon in the geographic spaces. In China, thousands of logistics industry gathering areas, but functional layout is unreasonable and industrial chain is fragile. The logistics

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industry gathering basic carrying capacity is an important guarantee for regional economic development, has a significant stimulating effect on the improving the regional distribution of productive forces, production relations changes and the quality of economic operation. The key to enhance the basic carrying capacity of the logistics industry gathering area is the rationalization of the spatial layout of the logistics cluster area. At present, the theory of logistics industry gathering logistics center city layout is feasible, but the actual operation is difficult (Shi 2005). With further research, there has been a fuzzy comprehensive evaluation method (Chen and Liu 2006), analytic hierarchy process (Sun and Wei 2002). However, these methods only be evaluated from a particular point of view, the credibility of the results is poor.

132.2 Logistics Agglomeration Externalities Influence the Formation of the Regional Logistics Infrastructure Carrying Capacity

The enterprises on the logistics gathering area by gathering the regional public service platform, realizing the infrastructure sharing, information sharing, full unimpeded flow of information on the logistics chain, achieving value-added on the agglomeration economies of scale, enhancing its overall competitiveness (Rust et al. 2001). Logistics agglomeration externalities influence the formation of the logistics infrastructure carrying capacity directly. Logistics industrial basic carrying capacity is the network for logistics nodes to attract and cohesion in the regional economy. The logistics cluster spatial distribution capacity could diffusion on the surrounding area. Diffusion of material elements and the role of non-material elements function on the nearby region, combination with the regional factors of production, forming a new productivity, promoting social and economic development. In the process of regional economic development, “infrastructure beam” forming industrial cluster zone. Due to differences in different regions of geographic base and economic development characteristics, regional logistics network during the formation has different form of intrinsic motivation and evolution. (Yang 2006) from the development characteristics of China’s logistics industry cluster analysis, found regional differences are obvious, showed strong production of the eastern coast and outward economic orientation of the resistance from the spatial distribution (Han et al. 2002). Foreign countries study the logistics capabilities almost from the microscopic point; he study on the logistics capacity just around a single enterprise. The study on the regional logistics capability is rare. Daughery and Pittman (1995) from the perspective of resources thought that logistics capability is part of the enterprise resources and control by the corporate (Daughery and Pittman 1995). Michigan State University Global Logistics Research Team divided logistics capabilities into thirty-two kinds, 17 kinds of generic logistics capabilities, information technology and flexibility is the most important logistics capability (Anonymous 1995). Lynch et al. (2000) divided logistics capabilities into two parts, the processing capabilities and value-added capabilities and study the relationship between its performance and logistics (Lynch et al. 2000). Zhao et al. (2001) focused on “customer focus” and “information focus” two angles summarized the factors affecting the performance of logistics capabilities, including segmentation focus, association, response, flexibility, IT, information sharing and connectivity research and logistics capability this seven elements (Zhao et al. 2001; Shang and Peter 2005). The survey of 1200 manufacturing and processing enterprises in Taiwan, found information-based logistics is a key factor affecting the performance, including affect the benchmarking capability, flexible capacity and logistics performance (Shang and Peter 2005). Domestic scholars (Ma 2005) thought that the logistics capabilities is the objective capacity formed by the logistics system of the structure of matter (such as the number of distribution centers and the scale of the transport capacity, sorting and processing equipment capacity, etc.), based on the logistics capabilities of the formation of logistics elements of the ability to quantify, built the initial model (Ma 2005). Yan (2005) was studied the capacity of the regional logistics demand and supply from the point of view of the system (Yan 2005). Cheng (2008) used factor analysis method, studied the evaluation of logistics capabilities, and the results showed that could evaluation the logistics capability from the customer service, reliability, distribution range, and information processing (Cheng 2008). The above studies study the concept of logistics capabilities, elements, evaluation and performance, but few scholar systematic analysis the key elements of regional logistics infrastructure carrying capacity.

132.3 The Factors Affecting the Regional Logistics Infrastructure Carrying Capacity

The basis carrying capacity of logistics industry gathering area is an important factor to ensure the logistics industry gathering area layout program and the construction scale, the amount of logistics is one of the major determining factors (Yang et al. 2006). Many elements affected the level of regional logistics development, mainly in the following five aspects (Zhang 2005). Firstly, the development level of the area’s national economy overall. The logistics industry cluster area is the product of economic development to a certain stage, the overall development of the national economy in the level of the logistics industry gathering area layout planning and construction is the important macro-environmental conditions. Secondly, the development level of industrial and commercial. Industry and commerce is the principal object of the logistics services, and its level affect the operational efficiency of the logistics industry gathering area directly, is an important basis to determine the logistics industry gathering space layout vectors city level category. Third, the development level of the transportation.

Transport is the main logistics activities, the development of the transport industry and transport size impact on the level of development of logistics and logistics industry gathering area site planning scale directly. Fourth, the development level of the Foreign Trade and Economic. The area with high development level Foreign Trade and Economic objectively needs the supportive of the international high-level logistics industry gathering area for the international logistics operations, affecting strategic planning and positioning of the logistics industry gathering area. Fifth, the Social Infrastructure. The logistics industry needs massive investment in infrastructure, the level of development of social infrastructure could support or restrict the rapid development of the logistics industry gathering area. Specifically as is shown in Table 132.1.

132.4 The Evaluation on the Regional Logistics Infrastructure Carrying Capacity

The paper used the factor analysis, by finding the common factors of many indicators and simplifying the complex relationships that existed in the indexes, given the factor scores for each regional sample, but the gradient partition of each sample should be considered in the aggregation of the multi-index space, so use of cluster analysis to cluster the similar indicators, in order to combine the factor scores to obtain the optimal solution of regional logistics agglomeration area location.

First, collected the data based on the influencing factors, then normalized the raw data, as the amount of logistics be a reference sequence, to calculate the gray correlation coefficient. $X_0 = \{X_0(k)|k = 1, 2, \ldots, n\}$, The influencing factors as comparative sequence: $X_i = \{X_i(k)|k = 1, 2, \ldots, n\}(i = 1, 2, \ldots, m)$.

$$\xi_i(k) = \frac{\min_i \min_k |X_0(k) - X_i(k)| + \rho \max_i \max_k |X_0(k) - (k)|}{|X_0(k) - X_i(k)| + \rho \max_i \max_k |X_0(k) - X_i(k)|} \tag{132.1}$$

$\rho \in (0, +\infty)$, called the distinguishing coefficient, ρ the smaller, the greater the resolution, the general range of ρ values [0, 1], depending on the circumstances, and $\rho \leq 0.5463$. The resolution is best, usually taken $\rho = 0.5$ which can be obtained the correlation coefficient $\xi_i(k)$ between $X_i(k)$ and $X_0(k)$.

Second, the gray relational grades were calculated. The gray absolute relational degree that evaluation factors for the reference sequence is:

$$r_i = \frac{1}{n}\sum_{k=1}^{n} \xi_i(k). \tag{132.2}$$

Third, sort according to the size of the gray relational.

Fourth, using statistical analysis software SPSS13.0 for factor analysis, calculated the factor score by principal component analysis method for each city and

Table 132.1 The factors affected the logistics and industrial clustering

Variable	Index	Indicators describe	Unit
The supply and demand levels of the logistics market	Amount of logistics X0	Cargo	The thousand tons
The development level of the area's national economy overall	GDP X1	The total level of regional economic	One hundred million yuan
	The growth rate of GDP X2	Regional economic development prospects	%
	Gross fixed investment of the society as a whole X3	The total investment in fixed assets	One hundred million yuan
	Industrial output value X4	Level of industrial development	One hundred million yuan
	The growth rate of industrial output value X5	Industrial development, the level of growth	%
	Industrial added value X6	Potential scale of the industrial markets' logistics customer	One hundred million yuan
The development level of industrial and commercial	Industrial added value rate X7	Potential scale of growth of the industrial market logistics customers	%
	Industrial product sales revenue X8	Level of industrial development	One hundred million yuan
	Total retail sales of social consumer goods X9	The scale of the retail market	One hundred million yuan
	Total wholesale and retail X10	Level of commercial development	One hundred million yuan
The development level of the transportation	Freight turnover X11	Reflect the regional scale of the transport of goods	Billion ton-km
The development level of the Foreign Trade and Economic	Total imports and exports X12	Development of foreign trade scale	Ten thousand U.S. dollars
	The actual utilization of foreign resources X13	Utilization of foreign capital scale	Ten thousand U.S. dollars
Social infrastructure	Investment in Capital Construction X14	The level of infrastructure	One hundred million yuan

received the agglomeration of the same category by cluster analysis. According to the clustering statistic, distinct the urban samples based on closely relationships. Then determine the ideal logistics parks.

132.5 Analysis of the Hubei Province Regional Logistics Infrastructure Carrying Capacity

Hubei is located in the hinterland of the Central Plains, the middle reaches of the Yangtze River, east and west, south and north, the advantages obviously, is an important regional logistics distribution center in the middle. The paper used the gray relational analysis to make a scientific evaluation the space layout of the Hubei Province regional logistics infrastructure carrying capacity.

First, establish the evaluation index system.

Collected data in the Hubei Statistical Yearbook 2001–2010, calculated the gray relational coefficient, k = 1, 2…14. Absolute correlation degree of each comparative sequence to reference sequences is as follows:

$r_i = (r_1, r_2, \ldots r_{14}) =$ (0.734839487, 0.663005684, 0.754054, 0.773217806, 0.68196788, 0.74926948, 0.513972255, 0.779459931, 0.732831774, 0.782822201, 0.827469312, 0.807581443, 0.77954827, 0.756834117). Finally, sort the evaluation results as are shown in Table 132.2. The results showed that the correlation degree between freight volume and the amount of logistics is the biggest.

Second, selecting the gray relational grade which is greater than 0.70 eleven index site index system as a regional logistics agglomeration, calculating the factor score by SPSS13.0 statistical analysis software. Wuhan score significantly better than other cities in Hubei, obtained two categories during cluster analysis, Wuhan as a separate category, other states all classified to a class. Wuhan behind in a class, the other cities again for factor analysis, test the extract the factors. Regarded as Bartlett sphere test F value is equal to 0.000, KMO value is 0.741, indicating that it is better to factor analysis. In accordance with the principle of cumulative variance contribution is greater than 85 % of the common factor of 3, as is shown in Table 132.3.

Built the original factor loading matrix with the main factor components F1, F2 and F3, obtained the maximum variance orthogonal rotation matrix, as is shown in Table 132.4.

The third main factor is the foreign factor. Calculation of factor scores and integrated factor score are shown in Table 132.5.

Third, using cluster analysis in accordance with the factor scores of Table 132.3 by the component connection method, distance measure the Euclidean distance. Hubei is divided into Wuhan, Xiangfan and Yichang for No. 1 logistics cluster area in Wuhan, XiangShi and JingYi three logistics circles, informing Hubei regional logistics service network, in order to serve in Wuhan, XiangShi and Jingyi three logistics circles better, to promote regional economic development.

Table 132.2 The correlation degree sorting of the compares sequence and the reference sequence

Index number	Index name	Light-linking	Sort
X11	Freight turnover	0.827469	1
X12	Total imports and exports	0.807581	2
X10	Total wholesale and retail	0.782822	3
X13	The actual utilization of foreign resources	0.779548	4
X8	Industrial product sales revenue	0.77946	5
X4	Industrial output value	0.773218	6
X14	Investment in Capital Construction	0.756832	7
X3	Gross fixed investment of the society as a whole	0.754055	8
X6	Industrial added value	0.749269	9
X1	GDP	0.734839	10
X9	Total retail sales of social consumer goods	0.732832	11
X5	The growth rate of industrial output value	0.681968	12
X2	The growth rate of GDP	0.663006	13
X7	Industrial added value rate	0.513972	14

Table 132.3 Cumulative contribution of variance and variance

Factor	Variance (%)	The cumulative contribution (%)	Variance after rotation (%)	Cumulative contribution after rotation (%)
1	72.448	72.448	40.201	40.201
2	10.316	82.764	28.073	68.274
3	8.244	91.008	22.734	91.008

Table 132.4 Rotated factor loading matrix

Index	Primary factor loadings		
	1	2	3
Investment in Capital Construction	0.829	0.243	0.224
Industrial added value	0.818	0.371	0.369
Gross fixed investment of the society as a whole	0.789	0.486	0.162
Industrial output value	0.783	0.370	0.322
Industrial product sales revenue	0.774	0.210	0.316
Total retail sales of social consumer goods	0.462	0.863	0.191
Total wholesale and retail	0.504	0.829	0.191
GDP	0.670	0.696	0.220
Freight turnover	0.040	0.686	0.666
Total imports and exports	0.307	0.287	0.882
The actual utilization of foreign resources	0.467	0.062	0.861

Table 132.5 Factor score and integrated factor score

Factor	Factor 1 score	Factor 2 score	Factor 3 score	Integrated factor score
HuangShi	−0.11704	−0.59955	3.20531	0.56
ShiYan	1.16827	−0.50054	−0.69638	0.19
YiChang	2.83088	0.22544	0.59101	1.47
XiangHuang	0.83313	1.65186	−0.54171	0.74
Ezhou	−0.31666	−0.85061	0.07157	−0.38
JingMen	0.22388	−0.14456	0.02200	0.06
XiaoGan	−0.02787	0.78590	−0.69381	0.05
JingZhou	−1.42584	2.38777	0.86905	0.32
HuangGang	−0.15802	0.82936	−0.53967	0.05
XianNing	−0.29574	−0.38449	−0.59091	−0.40
SuiZhou	−0.47871	−0.28272	−0.27896	−0.37
EnShi	−0.41952	−0.69869	−0.63348	−0.56
XianTao	−0.61398	−0.69163	−0.22163	−0.54
QianJiang	−0.85000	−0.56991	−0.40223	−0.65
TianMen	−0.33278	−1.15764	−0.16015	−0.54

132.6 Conclusion

As the regional economy is a significant urban–rural dual structure, the regional economic system constitutes by the core economic circle and the outer economic circle. The core economic circle is the inner circle of the regional economy, its resources, markets, technology and environment made the industrial structure combined effect, influenced the status of leader and guide on the regional economy; outer economic circle is affected by the core economic circle, due to geographical factors and relatively independent of the economic area, the city region serves the center of the city's industrial division of labor and cooperation, the formation of a small area of the city sub-centers, radiation rural centers. In conclusion, the economic circle of logistics constituted the three logistics "pole" to form the "point- axis- pole" logistics architecture. Built the core logistics circle oriented regional modern logistics industry gathering area, enhancing the regional logistics infrastructure carrying capacity, reflecting the central city of the "polarization" and "nuclear" effect, is extremely important strategic choice for urbanization, information technology, and industrialization on the region.

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Chapter 133
The Integration Model of Supply Chain Resource Allocation: LRP

Yan-yan Li and Wei Long

Abstract Materials Resource Planning (MRP) is a resource allocation technology in the production, which can achieve a target that hold variety of components and raw materials according to the demand planning and assembly in place, but not for circulation. Distribution Resource Planning (DRP) is a circulation of material resources technology, which can realize the circulation of material resources, but does not apply to the areas of production. If an enterprise engaged in both production and circulation, then requires a new approach. On the basis of the MRP and DRP, we discuss a logistics means of the material resource allocation—Logistics Resource Planning (LRP), which is the integration of MRP and DRP.

Keywords DRP · LRP · MRP · Supply chain

133.1 Introduction

In modern production, the mission of supply chain management is that make materials, funds in reasonable planning and on scheduling. So the planning and scheduling is a key link to reflect the efficiency and effectiveness of the supply chain. Among the parts of the supply chain, suppliers, manufacturers, distributors and other entities have the feature of geographical dispersion and terms of reference. There are many types of multiple orders in the parallel plan, such as in coordination, scheduling, execution and other business (Chai 2000; Chai and Dong 2000; Harland 1997). Traditional methods (MRP/DRP method) is generally like a centralized management, which ignored the autonomy, and serial hierarchical planning, and too much emphasis on the stability of the partnership, so, it is

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difficult to adapt to rapidly changing of market environment (Han et al. 1998; Zhang 1997). This paper presents a hierarchical planning and scheduling model based on logistics to meet the needs of supply chain management.

133.2 MRP and DRP

MRP is a material program management for production enterprise. It is based on the associated production plan and to develop the production material requirements planning, control instructions, and to achieve the control objectives of the inventory optimization. MRP make all required materials by the appropriate amount at the right time to reach the position. It is just to achieve the effective allocation of material resources. Generally there is no product excess work in process inventory (Bras and Mcintosh 1999; Gao 2009; Wang et al. 2008; Zhu and Pan 2003).

Though, MRP has been developed for many years, but the problem of multi-plant and multi-inventory issues has not been solved. It can not meet the needs of large-scale manufacturing enterprises in the distribution sector and the need of independent distributors of the industry. With the MRP gradually extended in the manufacturing industry, the needs of computer program management in the area of distribution has become more strongly. As the thinking of MRP in production area, DRP in distribution is appeared and applied. In the actual distribution process, product inventory is often located in a complex state, including regional warehouses, real-time distribution centers and factories. In such an environment, the main task of DRP is to manage factories and markets products. It is similar to MRP in manufacturing, the model of MRP and DRP are shown in Fig. 133.1 (Kong and Ge 2012; Wang and Cai 2007; Yuan and Xu 2011).

133.3 Technology Background of LRP

With the development of MRP and DRP, the addition is shown superiority, but also exposed their limitations.

133.3.1 The Connection of Production System and Circulation System

The production system is regularity and material demand is certainty, so MRP can make very detailed material requirements planning. But the implementation to the circulation is very complex. There are a large number of random factors, which

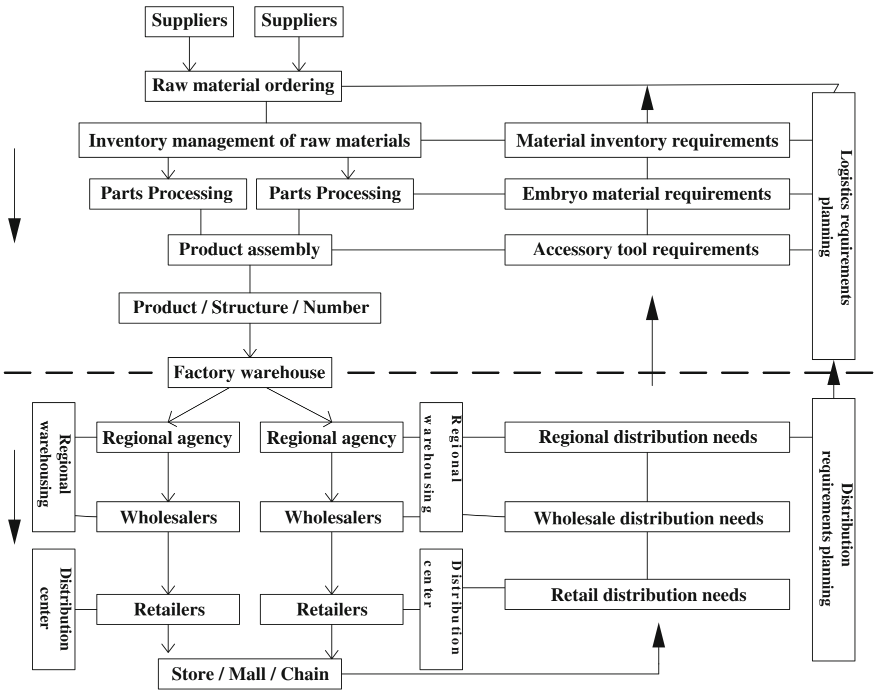

Fig. 133.1 The model of MRP and DRP

caused the material to raise the uncertainty, at the same time, effects in the implementation process is greatly reduced, which affects the result of the MRP.

The same problem also happened to DRP. The circulation center of the DRP can produce an accurate distribution requirements planning, but manufacturing plant and distribution center often appear randomness and can not guarantee the necessary material resources of the circulation center, then the distribution to the user is restricted. The effect of the DRP is affected (Chen 2008; Guo 2011; Yuan and Liu 2008).

133.3.2 Difference and Unity about MRP and DRP

Although DRP is application in circulation as MRP, they are consistent with the similar theory. But the characteristics of their respective fields are different, so they can not be simply applied. It should take some measures.

With the development of economy, enterprises need to competition, the scope of business continues to expand. They not only produce the product and also responsible for circulation; not only produce single product but also variety of products, or to carry out a wide range of services; not only in the region's market but also trans-regional or even worldwide market. Due to fierce market competition, in order to further improve resource utilization and economic benefits, they can not meet in the implementation of the MRP in the areas of production, nor the implementation of DRP in the circulation, and the need to combine them, using a cross-production and distribution, integrated and holistic material resource allocation techniques.

LRP emerged as the integration of MRP and DRP applications, and more and more people's attention it. The effect becomes obvious and the application prospect is potential (Liu 2008).

133.4 Principle of LRP

The basic idea of LRP is market-oriented and the basic means is logistics, which break the boundaries of production and circulation, and cost-effective for production and social circulation. It contains several basic points:

(1) Both for the social market demand and material resources. Meet society's material needs, organizational resources for the production and circulation of economic and efficient operation, including the effective organization of resources from the community and the internal economy.
(2) Break the boundaries of the production and circulation, allowing businesses in the market for the enterprise, and material resource allocation for social unity, and lower deployment costs.
(3) Flexibly use of various means to break the region, sector, ownership boundaries, using a variety of business organizations, business methods, as well as all kinds of logistics optimization method, in which way to achieve the efficient allocation of resources to improve economic efficiency.

LRP is established according to the principles, which is combination of MRP and DRP. Executive MRP within the production system, while DRP outside the plant. Logistics is the contact between the two parts.

The LRP principle is shown in Fig. 133.2. As can be seen from the figure, LRP is actually the integration of MRP and DRP. The system input master file of social needs, product structure file, production capacity file, logistics capabilities document, production costs, and supplier sourcing file, then output the production plans, capacity requirements planning, delivery planning and ordering stock plans, transportation plans, logistics capacity requirements planning, and cost accounting.

Master file of social needs (social order) is always first from DRP. When the stock is not enough, then purchase for the MRP order. General MRP is part of the DRP generated ordering purchase plan $P(t)$, the order of the production sector. The output of production plan MRP generates $T(t)$, plus the outsourcing plan $D_3(t)$ is input to the DRP. MRP according to the DRP production order purchase plan, the development of the production task list, resulting in the processing task orders to pay the processing of the production sector, purchased parts. DRP still start with

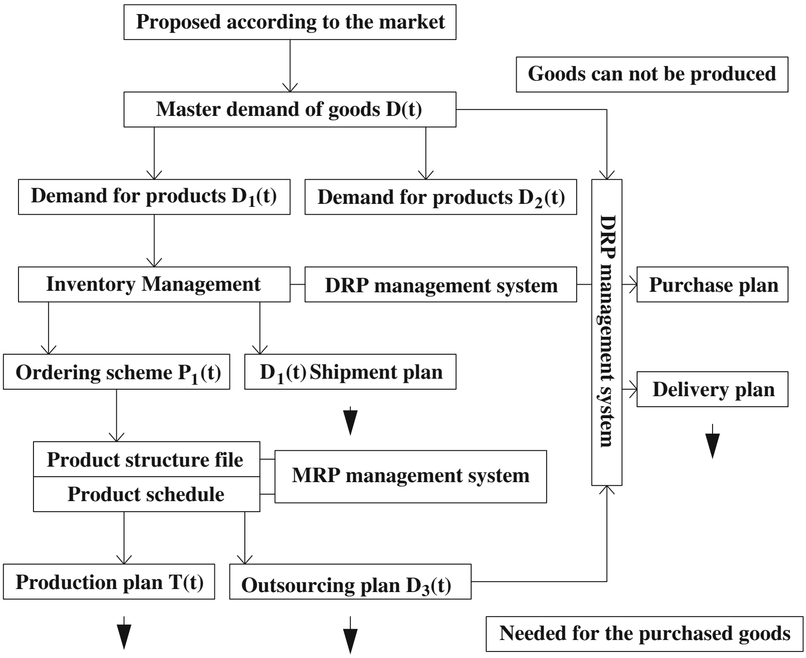

Fig. 133.2 LRP schematic

the warehouse supply, if warehouse is not enough by ordering purchase plan, then to the resource market to purchase stock.

D(t)—Master demand schedule—is the main products and components in the enterprise can produce itself (according to the enterprise product catalog).

$D_1(t)$ is run based on DRP, come to the need to purchase to the production department plan $P_1(t)$.

$D_1(t)$ is a part of the main requirements document $D(t)$, which companies can produce by themselves. This part of the DRP processing, always supply by inventory in the first, when the inventory down to the safety stock, then the production department to issue orders.

$D_2(t)$ is products are not produced by enterprise.
$D_3(t)$ is outsourcing plan.
$P(t)$ is market order plan.
$S(t)$ is delivery scheme.
$Os(t)$ is product delivery on the way.
$O_P(t)$ is product arrival or in-transit (storage).

Implementation can be divided into the following three steps:

Step (1) Parameter is determined by the following formula:

$$Q(t) = Q(t-1) - D_1(t) \tag{133.1}$$

$$P'(t) = Q_0(t) \tag{133.2}$$

$$P_1(t) = P'(t - t_P) \tag{133.3}$$

Q (t) is the current stocks.
Q (t−1) is the volume of the inventory.
$Q_0(t)$ is the ordering bulk.
P' (t) is the current plan.
t_P is the Lead time.

Step (2) Based P_1(t), run MRP, we can get product put into scheme *T(t)* and its components outsourcing plan $D_3(t)$.

Step (3) Put $D_2(t)$ and $D_3(t)$ to the DRP run, come to the *P(t)* and *S(t)*, we can get $O_S(t)$ and $O_P(t)$.

Q(t) is calculated by the following formula:

$$Q(t) = Q(t-1) - D_2(t) - D_3(t) + O_S(t) + O_P(t) \tag{133.4}$$

P'(t) is determined as below:

when *Q(t)* dropped below the reorder point (or safety stock), it is necessary to arrange an arrival, its offer is equal to an order Q_0.

$$P'(t) = Q_0 \tag{133.5}$$

While ordering purchase plan:

$$P(t) = P'(t - t_P) \tag{133.6}$$

Delivery plan *S(t)* is:

$$S(t - t_S) = D(t), \tag{133.7}$$

t_S is the delivery lead time.

Through these three-steps, we can get ordering stock plans, procurement plans, production plans and delivery plans. In fact, if we input conditions of the logistics capacity (storage and transportation conditions, etc.), logistics optimization model, the cost of documents, we can also get the logistics capacity planning, unified transportation programs and logistics costs.

133.5 Conclusion

MRP system from the manufacturing plant and DRP system from distribution center are demand for access to data respectively. Due to types of products of two markets, the two systems usually separate their own data. LRP is a combination of MRP and DRP applications, which manage logistics and resource throughout the enterprise purchase of raw materials, product manufacturing, product distribution, aiming for the entire market, an effective management tool to reduce production costs.

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Chapter 134
The Inventory Demand Forecasting Model of the Regional Logistics Network in Supply Chain

Zou An-Quan and Huang Ren-Cun

Abstract This article is conducting a study on the demand forecast from the x-retailers, y-distribution centers, z-suppliers supply chain of logistics area. The supply chain will be divided into upstream and downstream levels. Combined with the characteristics of the supply chain and demand characteristics of the regional logistics network, Dijkstra shortest path algorithm is used and its demand forecast model is constructed based on it to obtain the exact demand of each node enterprises. At last, an example is given to prove it.

Keywords Exoskeleton arm · Hybrid fuzzy control · Pneumatic force-feedback · Teleoperation

134.1 Introduction

At in recent years, Logistics has been developing rapidly for enterprise's emphasizes on the third profit source in Logistics, huge support to Logistics from government, and numerous researches from experts and scholars. However, there is also bottleneck in the process of logistical development, such as higher expense and lower level of service. Thus, it is indispensible to solve that how to decrease

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the expense and increase the service quality. Supply chain is a functional network inventory made up of suppliers, manufacturers, retailers and clients. The word network inventory is defined as assembly of interrelated organizations and facilities in logistical process by the national standard logistic term. Regional network inventory, actually, is a complex network system made up of logistical node and interrelated parts in region. So, on account of the regional network inventory in supply chain, enterprises in every node should consider the forecasting problem. Not only the expense and profit of the company but also the expense of the whole supply chain should be considered so that make the mutual benefit and win and decrease the total expense in the society.

Current problem on demand forecasting is the supply period and demand uncertainties. And recently, application of supplier inventory management model (VMI) could eliminate the impact of the supply period uncertainty. But the demand uncertainty remains to solve. Because the demand uncertainty is mainly reflected in huge preference of clients, many enterprises in every node choose the suppliers depending on the shortest distance, for diminishing expense. Whereas, in a certain region, it exist a situation that there are variances in different distances between distribution center and supplier demand, though they are certain and stable that the potential total demand of client and the total demand of distribution center. Main domestic demand forecasting methods are not suitable for this situation currently such as differential equation model, time series model, grey forecasting theory model, BP neural network model. Therefore, the authors constructed an accurate demand forecasting model combined characteristics of supply chain and network in the situation, for forecasting demand, reducing expense and improving the service level.

134.2 Model Description

In this paper, on the premise of every logistic node fixed, the author researched on the supply chain network is a complex one composed of many retailers, distribution centers and suppliers. In the network, the nodes stand for retailers, distribution centers and suppliers, and the edge is the actual road. And every node is interdependent.

134.2.1 The Assumptions of the Mode

In a region, retailers have some demands on distribution centers, and they also hold demands on suppliers. Considering the expenses of logistics and transportation, logistics service level and randomness of shopping, retailers take goods from one or several distribution centers, and the amount of goods that retailers take depends on distance from a distribution center to a retailer, that is retailers take more goods from close distribution center and less goods from far distribution center. Similarly, distribution centers chose the closest supplier providing goods, but every distribution center could only chose one supplier, differently. Next, there are such assumptions:

(1) In a certain region, there are x retailers r, y distribution centers d, z suppliers s.
(2) Assumed the locations of retailers, distribution centers and supplier are defined.
(3) Demands of every retailer are defined and equal. Let $Q_r = 1$.
(4) Retailers have a certain demand to distribution centers, let q_r^d.
(5) Considering the randomness and subjectivity of consumers choosing commodities, assume retailers choose distribution centers only depending on the distance l_{rd}, q_r^d is inversely proportional to l_{rd}.
(6) Distribution centers have demand on suppliers, let as q_d^s.
(7) On account of factors, such as expense of transportation, assume that distribution center choose suppliers only depending on distance l_{ds}, that is every distribution center only choose one, the closest suppliers.

Symbol	Implication
$r(1,\ldots,x)$	There are x retailers.
$d(1,\ldots,y)$	There are y distribution centers.
$s(1,\ldots,z)$	At there are z suppliers.
q_r^d, q_d^s	The amount that retailer demand to distribution center, the amount that distribution center demand to supplier
l_{rd}, l_{ds}	The distance from a retailer to a distribution center, the distance from a distribution center from a supplier.
Q_r, Q_{d}, Q_s	The total demand of retailers, the total demand of distribution centers and the total demand of suppliers

134.2.2 Parameters of Model Contribution

134.2.2.1 Logistics Network Weighted Matrix

According to graph theory, logistics network picture could be described an assembly of a finite number of peaks $V = \{v_1, v_2, \ldots, v_n\}$, and an assembly that represents the relationships with these peaks $L = \{l_1, l_2, \ldots, l_m\}$. The picture is marked as $G = (V, L)$. And the weights of the side of any two nodes i and j are marked as w_{ij}. And the following network picture is the weighted network one (Figs. 134.1, 134.2).

Let the weighted network picture be described as a weighted matrix, there are several conditions in the following:

(1) If there is no side between any two nodes i and j in the picture, $w_{ij} = \infty$.

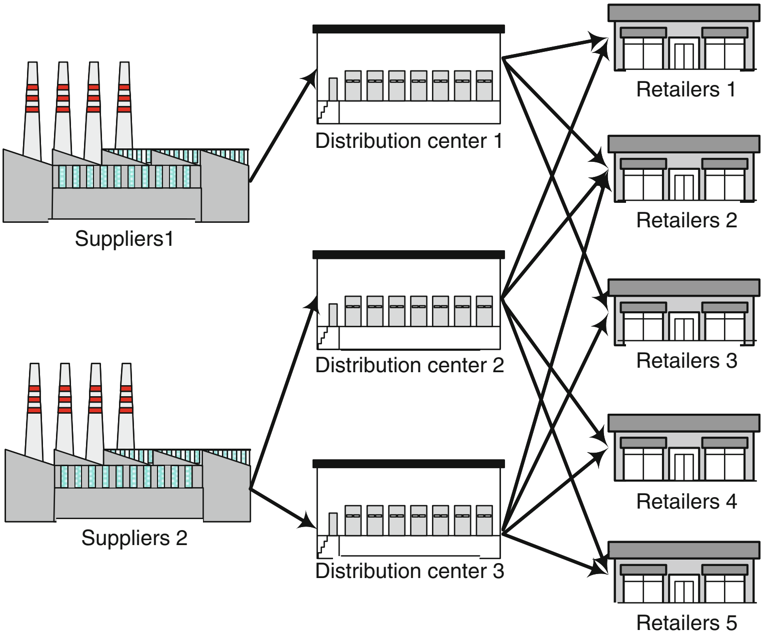
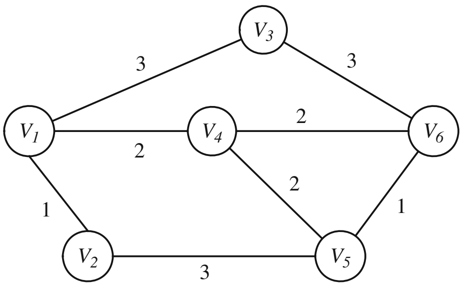


Fig. 134.1 Supply chain structure diagram

Fig. 134.2 Regional network picture



(2) If there is side between any two nodes i and j in the picture, w_{ij} is the side weighted value.

(3) If the two nodes i and j are coincided, $w_{ij} = 0$. So, we could conclude a weighted matrix (134.1) display the picture 2.

$$W = \begin{bmatrix} 0 & 1 & 3 & 2 & \infty & \infty \\ 1 & 0 & \infty & \infty & 3 & \infty \\ 3 & \infty & 0 & \infty & \infty & 3 \\ 2 & \infty & \infty & 0 & 2 & 2 \\ \infty & 3 & \infty & 2 & 0 & 1 \\ \infty & \infty & 3 & 2 & 1 & 0 \end{bmatrix} \tag{134.1}$$

134.2.2.2 Dijkstra Function to Find the Shortest Route Matrix

The shortest route problem is started with any node in the network picture, and to find the shortest route from the node to any other node in the network picture. The function proposed by Dijkstra, actually and currently, is great function to find the shortest route. The basic steps are in the following:

(1) Let the first note as i, the shortest distance $D_{ii} = 0$, then let the node i marked by 0 mark in the small square, representing that the node i marked.
(2) Start from i and find the point with the shortest distance, and let it as j, and let the symbol $D_{ij} = D_{ii} + w_{ij}$ be marked in the small square, representing that the node j have been marked.
(3) Start from marked node, and find the several points which have not been marked, marked as p. If there is $D_{ip} = \min\{D_{ii} + w_{ip}, D_{ij} + w_{jp}\}$, then give the p number, and let the D_{ip} be marked beside p.
(4) Repeat the step 3 again, until the last pointed marked. Now, we can use these steps above and combine related conditions in order to solve the matrix.

In the shortest route from retailer r to distribution center d, l_{rd} represents the actual distance from r to d, and D_{rd} represents the shortest distance from r to d. According to the steps in Dijkstra function, we could find out the shortest route formula $D_{rd} = \min\{D_{rd}, D_{rd} + l_{rd}\}$, to find out the matrix (134.2) that could conclude the shortest route model.

$$D_{rd} = \begin{bmatrix} D_{11} & D_{12} & \dots & D_{1y} \\ D_{21} & & & \\ \vdots & D_{rd} & & \vdots \\ D_{x1} & \dots & & D_{xy} \end{bmatrix} \tag{134.2}$$

Similarly considered the relevant conditions, we could conclude the matrix to find out the shortest distance from the distribution center and the suppliers, the forecasting model, as the (134.3) shows.

$$D_{ds} = \begin{bmatrix} D_{11} & D_{12} & \dots & D_{1z} \\ D_{21} & & & \\ \vdots & D_{ds} & & \vdots \\ D_{y1} & \dots & & D_{yz} \end{bmatrix} \tag{134.3}$$

134.3 Model Construction

We divided the model from upstream and downstream to construct. The upstream are the model forecasting the demand from retailers and distribution centers, and the downstream are the model forecasting the demand from distribution centers and suppliers.

134.3.1 Forecasting Model for the Demand from Retailers and Distribution Centers

The upstream supply chain includes retailers and distribution centers. According to the relevant parametric conditions above, we could construct the forecasting model depending on the demand from retailers and distribution centers.

(1) The demand of retailers r
Assumed the demand of every retailer are definite and equal, the total sum of every retailers taking goods from distribution is described as one unit.

$$Q_r = q_1^r + q_2^r + \cdots + q_y^r = \sum_{d=1}^{y} q_d^r = 1 \tag{134.4}$$

(2) The demand from distribution centers d
The total sum of the every retailer taking goods from distribution centers are the total demand from distribution centers. The demand function is as the (134.5) show:

$$Q_d = q_1^d + q_2^d + \cdots + q_x^d = \sum_{r=1}^{x} q_r^d \tag{134.5}$$

(3) The demand q_d^r is inversely proportional to the distance D_{rd}
The sum that every retailers demand the distribution centers is inversely proportional to the distance from retailers to distribution centers. And the relationship is as the (134.6) shows:

$$q_1^r : q_2^r : \cdots : q_y^r = \frac{1}{D_{r1}} : \frac{1}{D_{r2}} : \cdots : \frac{1}{D_{ry}} \tag{134.6}$$

(4) The construction of model
To conclude, we could find out the final forecasting demand model:

$$Q_d = q_1^d + q_2^d + \cdots + q_x^d = \sum_{r=1}^{x} q_r^d$$
$$s.t. \begin{cases} D_{rd} = \begin{bmatrix} D_{11} & D_{12} & \cdots & D_{1y} \\ D_{21} & & & \\ \vdots & D_{rd} & & \vdots \\ D_{x1} & \cdots & & D_{xy} \end{bmatrix} \\ Q_r = q_1^r + q_2^r + \cdots + q_y^r = \sum_{d=1}^{y} q_d^r = 1 \\ q_1^r : q_2^r : \cdots : q_y^r = \frac{1}{D_{r1}} : \frac{1}{D_{r2}} : \cdots : \frac{1}{D_{ry}} \end{cases} \tag{134.7}$$

134.3.2 The Model Forecasting Demand that Distribution Centers Demand Suppliers

Similarly, we could find out the model forecasting demand that distribution centers demand suppliers according to several relevant conditions above.

(1) To define the relationship that the demand q_d^s is inversely proportional to the distance l_{ds}.
If the distribution choose suitable suppliers, they should consider ability and frequency of the suppliers, and to the most important, they will consider the distance from distribution center to supplier. If so, it is possible to decrease the expense and increase the service level. Thus, in the model, the choice of suppliers should depend on the distance to fix, and every distribution centers choose the shortest distribution center. And the relationship is in the following:

$$q_d^s = \begin{cases} 1 & \min(l_{ds}) \\ 0 & others \end{cases} \tag{134.8}$$

(2) The demand of suppliers s,

$$\begin{gathered} Q_s = q_1^s + q_2^s + q_3^s + \cdots + q_y^s = \sum_{d=1}^{y} q_d^s \\ s.t. \begin{cases} D_{ds} = \begin{bmatrix} D_{11} & D_{12} & \ldots & D_{1z} \\ D_{21} & & & \\ \vdots & D_{ds} & & \vdots \\ D_{y1} & \ldots & & D_{yz} \end{bmatrix} \\ q_d^s = \begin{cases} 1 & \min(l_{ds}) \\ 0 & others \end{cases} \end{cases} \end{gathered} \tag{134.9}$$

134.3.3 The Model Forecasting Demand Depending on the Supply Chain

To conclude, in the region that with supply chain, the network model forecasting the demand is as the following show:

$$\begin{cases} Q_d = q_1^d + q_2^d + \cdots + q_x^d = \sum_{r=1}^{x} q_r^d \\ Q_s = q_1^s + q_2^s + \cdots + q_y^s = \sum_{d=1}^{y} q_d^s \end{cases}$$

$$s.t.\begin{cases} D_{rd} = \begin{bmatrix} D_{11} & D_{12} & \ldots & D_{1y} \\ D_{21} & & & \\ \vdots & D_{rd} & & \vdots \\ D_{x1} & \ldots & & D_{xy} \end{bmatrix} \\ Q_r = q_1^r + q_2^r + \cdots + q_y^r = \sum_{d=1}^{y} q_d^r = 1 \\ q_1^r : q_2^r : \cdots : q_y^r = \frac{1}{D_{r1}} : \frac{1}{D_{r2}} : \cdots : \frac{1}{D_{ry}} \end{cases}$$

$$s.t.\begin{cases} D_{ds} = \begin{bmatrix} D_{11} & D_{12} & \ldots & D_{1z} \\ D_{21} & & & \\ \vdots & D_{ds} & & \vdots \\ D_{y1} & \ldots & & D_{yz} \end{bmatrix} \\ q_d^s = \begin{cases} 1 & \min(l_{ds}) \\ 0 & others \end{cases} \end{cases}$$

134.4 An Instance Application

In order to examine the effect of the model, the paper is focused on a logistics network in Xiangtan supermarkets. And we use the model to forecast the demand. Picture 3 is a network of distributing good of the supermarkets. The star nodes s represent the suppliers location. The solid nodes d can be described the location of distribution centers. The hollow nodes r illustrate the retailers. And the sides of the every node stand for the actual distances. According to the description in the network, we could find out the network matrix, as the (134.11) shows:

$$A = \begin{bmatrix} 0 & \infty & \infty & 2 & \cdots & \infty & \infty & \infty & \infty \\ \infty & 0 & 3 & \infty & \cdots & \infty & \infty & \infty & \infty \\ \infty & 3 & 0 & 3 & \cdots & \infty & \infty & \infty & \infty \\ 2 & \infty & 3 & 0 & \cdots & \infty & \infty & \infty & \infty \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \infty & \infty & \infty & \infty & \cdots & 0 & 2 & 3 & \infty \\ \infty & \infty & \infty & \infty & \cdots & 2 & 0 & 3 & \infty \\ \infty & \infty & \infty & \infty & \cdots & 3 & 3 & 0 & \infty \\ \infty & \infty & \infty & \infty & \cdots & \infty & \infty & \infty & 0 \end{bmatrix} \tag{134.10}$$

Use the MATLAB and other programming tools, and combining the Dijkstra function to find out the shortest route matrix. And the D_{rd} matrix representing the shortest distance from retailers to distribution centers, as (134.12) shows:

$$D_{rd} = \begin{bmatrix} 2 & 10 & 12 & 13 & 14 \\ 10 & 8 & 13 & 17 & 18 \\ 7 & 5 & 10 & 14 & 15 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ 15 & 7 & 2 & 14 & 12 \\ 18 & 13 & 4 & 16 & 14 \end{bmatrix} \tag{134.11}$$

Similarly, the D_{ds} matrix standing for the shortest distance from distribution centers to suppliers, as (134.13) shows:

$$D_{ds} = \begin{bmatrix} 18 & 17 \\ 18 & 12 \\ 13 & 3 \\ 3 & 15 \\ 3 & 13 \end{bmatrix} \tag{134.12}$$

Now, we could use the model to find out the sum demand from distribution centers and suppliers respectively.

(1) The total demand from distribution centers:
Combining (134.12) with the matrix Q_d, we could get the (134.14)

$$Q_d = \begin{bmatrix} 0.6012 & 0.1202 & 0.1002 & 0.0925 & 0.0859 \\ 0.2402 & 0.3003 & 0.1848 & 0.1413 & 0.1334 \\ 0.2459 & 0.3443 & 0.1721 & 0.1229 & 0.1148 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ 0.0771 & 0.1653 & 0.5785 & 0.0826 & 0.0964 \\ 0.1076 & 0.1489 & 0.4841 & 0.1211 & 0.1383 \end{bmatrix} \tag{134.13}$$

Use the (134.14), we could find out the final total demand from 5 distribution centers

$$\begin{aligned} Q_{d_1} &= 0.6012+0.2402+\cdots+0.1076= 3.2583\\ Q_{d_1} &= 0.1202+0.3003+\cdots+0.1489= 4.4863\\ Q_{d_3} &= 0.1002+0.1848+\cdots+0.4841= 4.7734\\ Q_{d_4} &= 0.0925+0.1413+\cdots+0.1211= 2.6105\\ Q_{d_5} &= 0.0859+0.1334+\cdots+0.1383= 2.8715 \end{aligned} \tag{134.14}$$

And to do a further comparison, we could find out:

$$\begin{aligned} Q'_{d_1} &= \frac{Q_{d_1}}{Q_{d_1}+Q_{d_2}+Q_{d_3}} = \frac{3.2583}{18} = 0.18\\ Q'_{d_2} &= \frac{Q_{d_2}}{Q_{d_1}+Q_{d_2}+Q_{d_3}} = \frac{4.4863}{18} = 0.25\\ Q'_{d_3} &= \frac{Q_{d_3}}{Q_{d_1}+Q_{d_2}+Q_{d_3}} = \frac{4.7734}{18} = 0.27\\ Q'_{d_4} &= \frac{Q_{d_4}}{Q_{d_1}+Q_{d_2}+Q_{d_3}} = \frac{2.6105}{18} = 0.14\\ Q'_{d_5} &= \frac{Q_{d_5}}{Q_{d_1}+Q_{d_2}+Q_{d_3}} = \frac{2.8715}{18} = 0.16 \end{aligned} \tag{134.15}$$

As the (134.16) shows, the demand of distribution centers d_1 account 0.18, and d_2 accounting 0.25, d_3 making up 0.27, d_4 making up 0.14, d_5 making up 0.16. From this, we could know the proportions of the demand of every distribution centers.

(2) The total demand of suppliers
Combining (134.13) with the model, the total demand of suppliers as (134.17) shows:

$$\begin{aligned} Q_{s_1} &= Q_{d_4} + Q_{d_5} = 5.4820\\ Q_{s_2} &= Q_{d_1} + Q_{d_2} + Q_{d_3} = 12.5180 \end{aligned} \tag{134.16}$$

And make a further comparison:

$$\begin{aligned} Q'_{s_1} &= \frac{Q_{s_1}}{18} = \frac{5.4820}{18} = 0.3\\ Q'_{s_2} &= \frac{Q_{s_2}}{18} = \frac{12.5180}{18} = 0.7 \end{aligned} \tag{134.17}$$

The demand of supplier s makes up 0.3 in the whole supply chain, s2 making up 0.7. Now, the model has calculated the stock sum in suppliers and distribution centers exactly in the network.

134.5 Conclusions

This paper constructs a forecasting model, with graph theory and matrix knowledge, using the Dijkstra function, in the supply chain. And finally using MATLAB calculates the accurate demand. And the further research direction are: (1) How to construct a forecasting model considering the randomness, (2) How to let the model become more accurate with accurate expense in the model.

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Chapter 135
The Optimization Model of Airline Network on the Basis of Hub-and-Spoke

Fu-bin Pan, Zhi-sang Dai, Xiao-dan Gong and Jun-yi Wu

Abstract A high efficiency network is a strong support for the development of X Aviation Freight Transportation Company. To construct a scientific airline network is an important approach for airline companies to develop. Due to the extension of operating scale and uncertain requirement of cargo, it's necessary to build the hub-and-spoke airline network. This paper analyses the conditions and problems of X Aviation Freight Transportation Company firstly, then we build the optimization model of airline network on the basis of hub-and-spoke theory.

Keywords Discount-factor · Hub-airport · Logistics · The hub-and-spoke airline network

135.1 Introduction

In recent 30 years, the rapid development of air transportation has exceeded the intense competition in various aviation freight transportation companies. The aviation freight transportation has been a low-income with high investment industry especially in recent years. The quota in the market of air transportation is falling gradually. This phenomenon also exists in X Aviation Freight Transportation Company. How to lower the cost of the transportation and create a promising profit is the key point which the X Aviation Freight Transportation Company wants to deal with.

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135.2 Problem Analysis

Low loading rate, small coverage and unobvious scale efficiency are the three main problems of X Aviation Freight Transportation Company. Its flight mode is point-to-point, so that the company can't invest more capital on all-cargo aircrafts. It also results in the unbalance time and poor efficiency between different air routes. As the increasing demand of air transport market, airline network structure is experiencing the development process from point–point network to the hub-spoke airline network structure (Burghouwt and Hakfoort 2001).

135.3 The Hub-and-Spoke Airline Network Model

135.3.1 The Introduction of Hub-and-Spoke Theory

The hub-and-spoke theory is a method which can optimize the flow of the cargo by setting up centre hubs.

No matter the cargos go from different origins to different destinations or from the same origins to different destinations. The cargo must be transshipped at a centre hub in order to concentrate the goods measures and realize scale efficiency in the hub-and-spoke airline network.

The hub-and-spoke airline network divides the airports into hub-airports and non-hub-airports (Mou and Yang 2006). The hub-airport is a combination of various airports which results in the scale transportation among different hub-airports. At the same time, the hub-and-spoke airline network can optimize allocation of the airplanes. Every network structure has a connect with special market scale; hub and spoke airline network is a kind of flight network structure which can reflect the effect of the large-scale economy when airline transport market reaches a certain scale (Fig. 135.1).

135.3.2 The Development of Hub-and-Spoke Theory

Oum and Tretheway (1990) made an explanation on the change of airline structure from point–point airline network structure to hub-and-spoke airline network. At the same time, they analyzed the cost of airline and influence of travelers' time of hub-and-spoke airline network.

Lederer (1993) used the method of game theory to establish a model to analyze the choice of airline network structure under competitive environment. At the same time, Zhang and Wei also analyzed the effectiveness of hub and spoke airline network based on the same flexibility demand function in competition environment (Zhang and Wei 1993).

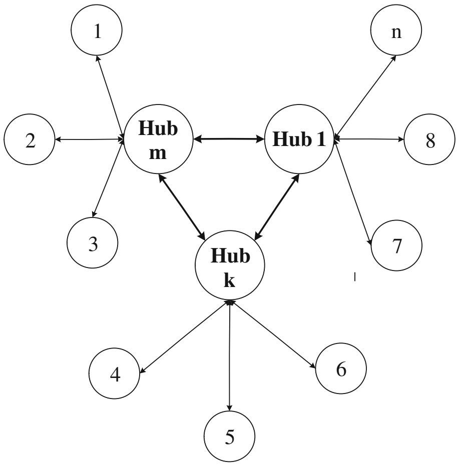

Fig. 135.1 The model of hub-and-spoke network

Oum et al. (1995) had conducted an in-depth study on the airline network choice based on literature. The choice criteria were the total cost saving (which included both airline and passenger inconvenience costs) and service quality improving. They found that hub-spoke network was still the first choice of airlines even if hubbing raised total cost.

135.3.3 The Model of Hub-and-Spoke Airline Network Model

X Aviation Freight Transportation Company aims to integrate the recent aviation resource and to optimize the airline network. It plans to choose some hub-airports which forming a hub-and-spoke airline network, so that it can achieve scale-benefit. Under the recent competitive environment, only the cost-reduce on operation can make the airlines in an invincible position in the survival of fittest (Adler 2001).

Firstly, we number the airline in different cities, form a set of N range from 1 to n. The number of hub-airline is p(p < n). (i, j) stands for the flow from origin to destination.

W_{ij}, C_{ij} respectively stands for the conveyance measures of O-D flow (i, j) and unit transport cost of per-weight cargo (Zhao 2003). Generally, the quantity is different in contrary flow, while the cost of unit cargo going back and forth is the same. So it can be concluded that $C_{ij} = C_{ji}$, $W_{ij} \neq W_{ji}$, $C_{ii} = 0$, $W_{ii} = 0$.

We make $\mathrm{Y} = \{\mathrm{y_k} | \mathrm{k} \in \mathrm{N}\}$, $\mathrm{y_k} = \begin{cases} 1, \mathrm{k} \in \mathrm{N} \\ 0, \mathrm{k} \notin \mathrm{N} \end{cases}$, N is the set of Hub-airports, $\|\mathrm{H}\| = \mathrm{p}$, $\mathrm{k} \in \mathrm{H}$, and $\mathrm{y_k} = 1$.

$X = \{x_{ikmj} | i, j,k,m \in N\}$, x_{ikmj} stands for the proportion of cargo quantity through the hub-airports against the total quantity. It's namely the proportion of the O-D flow going through the route $i \rightarrow k \rightarrow m \rightarrow j$ (k, m are hub points). The model is set up on the basis of the direct proportion between cost and distance. β is the discount-factor meaning the discount between the hub-airports. ∂, γ are the discount-factors between hub-airports and non-hub-airports (Hooper 1998). The goods carrying capacity between the hub-airports is massive, so that it can form the scale transport and make the cost lower. Generally, $1 = \beta = \gamma > \partial > 0$. We can build up the low cost network for X Aviation Freight Transportation Company through this model.

135.3.4 Building Model

The distances between airports of X Aviation Freight Transportation Company in each city can be attained through the Google map. We haven't specifically listed the distances here. The model is established subject to freight be in direct ratio to distance. The model is as follows:

$$Z = \text{Min} \sum_{i=1}^{n} \sum_{j=1}^{n} \sum_{k=1}^{n} \sum_{m=1}^{n} W_{ij} \left(\beta C_{ik} + \partial C_{km} + \gamma C_{mj} \right) x_{ijkm} \tag{135.1}$$

$$\text{S.T.} \quad \sum_{k=1}^{n} y_k = p \tag{135.2}$$

$$\sum_{k=1}^{n} \sum_{m=1}^{n} x_{ikmj} = 1, \ i, j = 1, \ldots, n \tag{135.3}$$

$$\sum_{m=1}^{n} x_{ikmj} \le y_k, i, j, m = 1, \ldots, n \tag{135.4}$$

$$\sum_{k=1}^{n} x_{ikmj} \le y_m, \ i, j, m = 1, \ldots, n \tag{135.5}$$

$$y_k \in \{0, 1\}, k = 1, \ldots, n, x_{ikmj} \ge 0, \ i, j, k, m = 1, \ldots, n \tag{135.6}$$

The meaning of variables:

N: The set of all nodes of aviation in network;
H: The set of all potential hub nodes in the network;
i, j: Origin nodes and destination nodes, $i, j \in N$;
k, m: The prospective hub nodes;
p: The number of hub nodes;

W_{ij}: The volume of O-D flow from node i to node j;
C_{ij}: The unit transport cost from node i to node j;
∂: The discount factor among hub nodes in the trunk transports;
x_{ikmj}: The decision variable. When numerical is 1, the route (i,k,m,j) is selected as O-D flow (i,j). It means goods from node i to node j through hub k and hub m; When numerical is 0, it won't be chosen;
x_{ikmj}: The path which each O-D flow passes through is limited to three sides at most;
$y_{k,}y_m$: 0–1 decision variable. When numerical is 1, it means node k or node m is a hub node;

The meaning of constraint equations:

Formula (135.1): Express that the aim of the model is the minimum cost of the airline network;
Formula (135.2): Limit the number of the hub-airports in the airline network;
Formula (135.3): Ensure that all the traffic of O-D flows deliver from the origin nodes to destination nodes;
Formula (135.4) and (135.5): Ensure that all the O-D flows transship through the hub cities only;
Formula (135.6): Require that the selected variables of hub airport to be 0–1 variables, the others are non-negative variables.
Formula $C_{ikmj} = \beta C_{ik} + \partial C_{km} + \gamma C_{mj}$: Express the total cost from node i to node j (Tables 135.1 and 135.2).

According to the growth of business of X Aviation Freight Transportation Company, we decide to choose three cities and four cities as aviation hub after considering different various condition of air discount factors. We usually select 0.5–0.8 as discount factors. Then we use Lingo11.0 mathematical software to solve the models dynamically. The result is as follows:

We can make the conclusion according to Table 135.3. The cost of the fourth row are all smaller than 1. It means the model of constructing hub-and-spoke airline network can make the cost lower. And the discount is subject to the scale efficiency between hubs. When we build the same numbers of hubs, the scale efficiency will be more remarkable, the discount factor will be smaller, the freight will become lower.

Table 135.1 City code

Code	City	Code	City
1	Beijing	6	Chengdu
2	Shanghai	7	Xi'an
3	Chongqing	8	Zhengzhou
4	Shenyang	9	Wuxi
5	Wuhan		

Table 135.2 Average traffic volume per day (unit: T)

No.	1	2	3	4	5	6	7	8	9
1	0	13	2	9	4	5	3.5	3.5	11
2	2	0	2	7	3	4	2	2	0
3	0.8	0.5	0	0.3	0.3	0	0.2	0.2	0.5
4	6	3	1	0	0.6	1	0.4	0.5	2
5	3	2	1	0.5	0	1	0.4	0.6	1.4
6	3	1	0	0.6	0.7	0	0.5	0.5	1.2
7	1.8	0.8	0	0.4	0.3	1	0	0.3	1
8	1.7	1.1	1	0.4	0.5	0	0.3	0	1
9	16	0	2	6	3	0	2.4	2.7	0

Table 135.3 Model results

	Hubs no.	Hub name	Relative cost
0.1	2	Beijing, Wuhan	0.517
	3	Beijing, Shanghai, Wuxi	0.503
0.2	2	Beijing, Wuhan	0.583
	3	Beijing, Shanghai, Wuxi	0.525
0.3	2	Beijing, Wuhan	0.645
	3	Beijing, Shanghai, Wuxi	0.609
0.4	2	Beijing, Wuhan	0.701
	3	Beijing, Shanghai, Wuxi	0.655
0.5	2	Beijing, Wuhan	0.755
	3	Beijing, Shanghai, Wuxi	0.700
0.6	2	Beijing, Wuhan	0.802
	3	Beijing, Wuhan, Xi'an	0.733
0.7	2	Beijing, Wuhan	0.829
	3	Beijing, Shanghai, Wuxi	0.794
0.8	2	Beijing, Wuhan	0.855
	3	Beijing, Wuhan, Wuxi	0.830
0.9	2	Beijing, Wuhan	0.889
	3	Beijing, Shanghai, Wuxi	0.835

135.4 Conclusion

The air transport industry in China has been grown rapidly in 21st century. The construction of hub and spoke airline network has been brought into strategic planning of Chinese civil aviation administration (Zhao 2005). Every aviation freight transportation company is searching methods to reduce cost. Building hub-and-spoke airline network can reduce transport costs and realize scale efficiency which will be widely used in the future.

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Chapter 136
The Research for Supply Chain Partner Selection of Real Estate Enterprise

Fu-zhou Luo and Yu-ze Wang

Abstract This paper aims at the characteristics and its components of the real estate supply chain, and analyzes the important meaning that implementing supply chain partners' management is thought to the real estate development enterprise (Ekambaram et al. 2001), and provides reasonable suggestions and measures to the real estate development enterprises' as how to implement the supply chain partner selection management means practically. In the process of implementation of the supply chain management, this paper makes use of quantitative and qualitative analysis methods. From the start of the game analysis, and emphasize the necessity of establishing strategic partner between upstream and downstream enterprises, and on the basic of the rule for the real estate industry supply chain partners' selection (Ertogral and David Wu 2000), proposes the use of scientific fuzzy comprehensive evaluation method to select suppliers and evaluation.

Keywords Game analysis · Partners · Real estate enterprise supply chain management · The fuzzy comprehensive evaluation method

136.1 Introduction

The real estate enterprise supply chain management is to the management of the whole business activities in essence, and not the traditional function division or the management of the local efficiency. Aim is that it will make the whole supply chain's advisory services, material equipment procurement, planning of the value, construction process, designing, selling and property management activities linked, provide the most value for customers and their own at the lowest cost in the

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shortest possible time, and in order to gain the competitive advantage (Akintoye et al. 2000). It is an important topic that the enterprise should face that includes improving the quality of supply chain management, keeping the enterprises' core ability, and making the enterprise's internal and external resources together effectively.

The essence of real estate enterprise supply chain management is integrating the core competitiveness of each node enterprise, and by establishing a strategic cooperative partnership between the core enterprise and its upstream and downstream enterprises to realize information sharing, controlling in time and agile manufacturing, and in the way of powerful combination, gaining the competitive advantage, and to achieve the win–win purpose.

Development design business, surveying, supervision company, bidding agent, contractors, materials and equipment suppliers will all be as a real estate enterprise's suppliers (Barker et al. 2000), while the real estate enterprise is an integration center of the related enterprise. Sales company and Property Company will be regarded as the real estate enterprise's downstream enterprises.

What the final purpose that real estate industry supply chain management mode implement is to reduce the total construction cost of the supply chain building products, and to shorten product delivery date by fully information sharing between enterprises (Simchi-Levi 2000), to enhance customer satisfaction, to improve product quality, and to generate more competitive advantage.

Real estate enterprise is in the position of client, after constructing the supply chain, partner selection is correct or not, can achieve expected returns or not, realization of strategic alliance or not, information sharing capability can adapt to the enterprise needs or not, are all worthy to our consideration and study.

This paper thoroughly researches the problem that real estate enterprise supply chain partners' choice, and provide decision-making basis for real estate enterprise's alliance partners of reasonable choice and partners of performance evaluation, meantime it can provide support and reference for real estate development's related economic activities of the government (Cooper et al. 2007), the relevant institutions and real estate investors.

136.2 Methodology

In the real estate industry supply chain, enterprise cooperates with other enterprises inevitably, and we can set game model's original game between enterprises into one-time static game of similar prisoners' dilemma. Assuming there are two enterprises of the relationship between mutual cooperation, respectively for enterprise 1 and enterprise 2. They respectively have two strategic choices in the one-time cooperation, that is trust and distrust (Black et al. 2000). All parties' profit not only depend on their own strategic choices, but also depend on the corresponding choice of the other side. When two enterprises choose to trust at the same time, both sides gain profit is (5,5); when they choose not to trust at the same time, the two enterprises

Table 136.1 Prisoners' dilemma analysis

Profit of all parties		Enterprise 2	
		Trust	Distrust
Enterprise 1	Trust	(5,5)	(−1,6)
	Distrust	(6,−1)	(1,1)

Table 136.2 Arrow method is used to solve the nash equibibrium

Profit of all parties		Enterprise 2		
		Trust		Distrust
Enterprise 1	Trust	(5,5)	→	(−1,6)
		↓		↓
	Distrust	(6,−1)	→	(1,1)

must stand on their own, the profit is (1,1); When one party choose to trust while the other is not, then the don't trust will gain six units of capital, while the trust party will be one unit of loss, that is both sides benefit for (6,1) or (1,6), this two enterprises' trust game benefit matrix is shown in Table 136.1.

Through the arrow method's solving can we wonder that (distrust, distrust) is only one Nash equilibrium of the static game (as Table 136.2). This shows that in the one-off cooperation the two enterprises will choose distrust that is not cooperative behavior for grab a greater profit from the angle of personal limited rationality when they meet conflicts of interest (Palaneeswaran et al. 2003). But the choice is not only not realize the optimal individual interests (each enterprise' benefit for the best is 6, but the choice that each had 1), but also don't make the optimal overall interests (the overall interests of the optimal for $5 + 5 = 10$, and the choice is $1 + 1 = 2$). To illustrate that individual's pursuit of the maximum interests behavior always can't lead to the best interest of the society, and often can't really realize their own best interests. In other words, Nash equilibrium does not necessarily lead to pareto optimality.

As a result, real estate enterprise shall establish cooperation partners, and choose from many partnerships, specific methods are as follows, using the fuzzy comprehensive evaluation model, using the results for the final choice.

136.3 Results

Real estate supply chain partners' evaluation index system' establishment should meet certain principles. First, it must fully reflect supplier of business enterprises' the comprehensive level at present, secondly, the size of the evaluation index system is appropriate, and it should be set a compared index system with others abroad. The most important is that the index system have flexibility, and enterprises can use the indexes flexibly accord to their characteristics and practice.

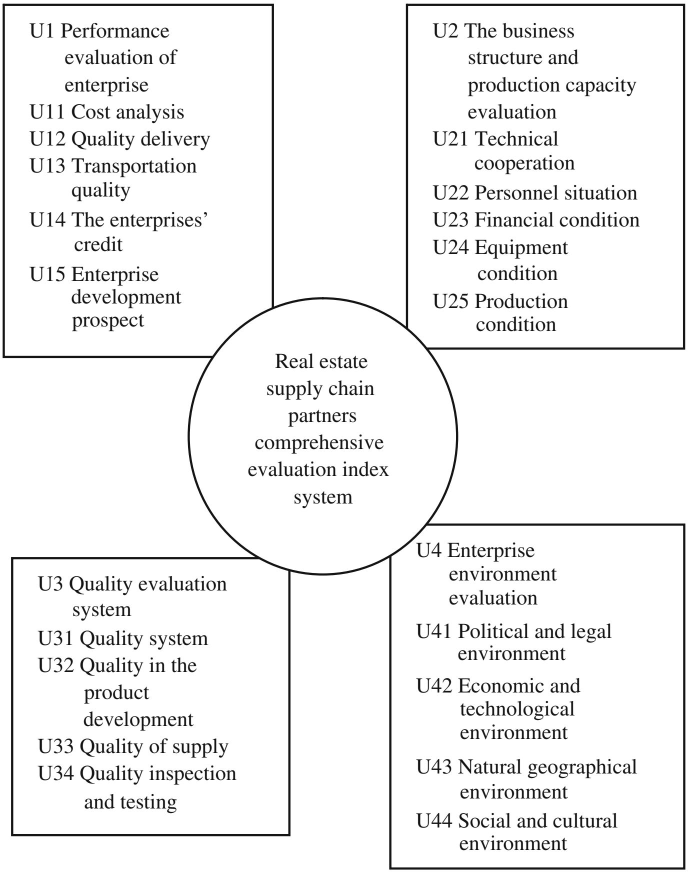

Fig. 136.1 Real estate supply chain partners comprehensive evaluation index system

The real estate industry supply chain partners comprehensive evaluation index system is the basis and standard of choosing real estate supply chain partners, it is a set that reflects real estate supply chain partners enterprise itself and a complex system's different attribute index of environment, according to the ownership, orderly composition of hierarchical structure (Hobbs and Andersen 2001).

In the basic of a large number of data acquisition and full market research, this paper compares the characteristics of engineering general contractor and its elements of the core competitiveness. It concludes real estate supply chain partners (total engineering contractor) comprehensive evaluation factors to four categories, that is enterprise performance evaluation U1, the business structure/production capacity evaluation U2, quality evaluation system U3, enterprise environment evaluation U4, each kind of factor decomposition into several factors again, to form a set of comprehensive evaluation factors system of relatively complete cooperation partner, as is shown in Fig. 136.1.

136.4 Discussion

136.4.1 Use the Weighted Statistics to Determine the Index Weight

The use of index to the comprehensive evaluation system of the general contractor is very much above, but each index in the final overall evaluation process' influence ability of the supplier is different due to the reasons that the company's industry background, the scale of the enterprise, the position of industry (Sun and Liu 2005). Therefore, when we evaluate suppliers comprehensively, we need to make a judgment to the important degree of different indicators, that is to determine the weights of the index, this is we must do the earlier work that scientific and comprehensive evaluation and selection to suppliers.

Weighted statistics is a qualitative and quantitative method of scientific decision; the specific practices are as Table 136.3.

Among them, x_i is weighted function value, Ni is frequency and continuous, and P_i is frequency.

Follow the formula $\mathrm{W_k} = \sum_{i=1}^{s} \mathrm{P_i N_i}$ and "*s*" is serial number, we can get the weights of request is that W = (0.53, 0.01, 0.29, 0.08).

According to this method, gaining the second indexes weights in turns. Respectively for:

W1 = (0.03, 0.09, 0.43, 0.05, 0.26),
W2 = (0.35, 0.13, 0.20, 0.18, 0.14),
W3 = (0.02, 0.14, 0.18, 0.24),
W4 = (0.32, 0.20, 0.23, 0.17).

136.4.2 Single Factor Membership Degree Evaluation

Divide the evaluation set of all real estate supply chain partners evaluation factors and evaluation son factors into five levels, namely V = {good, better, medium, a little poor, poor}. And then evaluate of single factor to the U1, U2, U3, U4 of the real estate supply chain partners, $\mathrm{R_i} = (\mathrm{r_{ij}}, \mathrm{k}), \mathrm{i} = 1, 2, \ldots, \mathrm{n_i}; \mathrm{j} = 1, 2, \ldots, \mathrm{n_i}, \mathrm{k} = 1, 2, \ldots, 5$. Among them n_i expresses the son factors' number under U_i,r_{ij},k expresses the son factor u_{ij} to the rating Y_k's degree of membership. Ascertaining R_i use the expert evaluation method. The specific process is: hire five to seven experts, and each experts aims at each son factors to play 1 points on the corresponding comments, and then take average respectively in every comment to every son factors after points, obtaining the final score (Selen 2003), and use this as the corresponding membership.

Hypothesis invited five real estate industries and engineering field experts to evaluate, they are three general contractors named Alan, Jack and Mike. As is shown in Table 136.4.

Table 136.3 Weighted statistics calculating weight value

Serial number	x_i U_i	N_i	P_i
i	U_1		
1	0.15	1	0.0455
2	0.20	4	0.182
3	0.25	5	0.227
4	0.29	1	0.0455
5	0.30	9	0.409
6	0.35	1	0.0455
i	U_2		
1	0.15	1	0.046
2	0.17	6	0.272
3	0.25	4	0.182
4	0.29	1	0.046
5	0.30	7	0.318
6	0.35	3	0.136
i	U_3		
1	0.20	5	0.227
2	0.25	3	0.136
3	0.29	1	0.046
4	0.30	7	0.318
5	0.35	4	0.182
6	0.40	2	0.091
i	U_4		
1	0.10	5	0.227
2	0.11	1	0.046
3	0.15	4	0.182
4	0.20	8	0.384
5	0.30	3	0.136
6	0.40	1	0.045

Now Alan is an example, according to the method of model above, calculating the single factor evaluation matrix of the second factor, and then we can get the result, that is:

$$R_1 = \begin{pmatrix} 0.4 & 0.4 & 0.2 & 0 & 0 \\ 0.4 & 0.6 & 0 & 0 & 0 \\ 0.6 & 0.2 & 0.2 & 0 & 0 \\ 0 & 0.6 & 0.4 & 0 & 0 \\ 0.2 & 0.2 & 0.6 & 0 & 0 \end{pmatrix}, \quad R_2 = \begin{pmatrix} 0.8 & 0.2 & 0 & 0 & 0 \\ 0.2 & 0.8 & 0 & 0 & 0 \\ 0 & 0.4 & 0.6 & 0 & 0 \\ 0 & 0.4 & 0.6 & 0 & 0 \\ 0 & 0.2 & 0.6 & 0.2 & 0 \end{pmatrix},$$

$$R_3 = \begin{pmatrix} 0.8 & 0.2 & 0 & 0 & 0 \\ 0.6 & 0.4 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0.2 & 0.8 & 0 & 0 & 0 \end{pmatrix}, \quad R_4 = \begin{pmatrix} 0.2 & 0.6 & 0.2 & 0 & 0 \\ 0.6 & 0.4 & 0 & 0 & 0 \\ 0 & 0.2 & 0.2 & 0.6 & 0 \\ 0 & 1 & 0 & 0 & 0 \end{pmatrix}.$$

Table 136.4 Single factor assessment form

Evaluation factors	Son factors	Comments level				
		Good	Better	Medium	A little poor	Poor
U1 Performance evaluation of enterprise	U_{11} Cost analysis	0.4	0.4	0.2	0	0
	U_{12} Quality delivery	0.4	0.6	0	0	0
	U_{13} Transportation quality	0.6	0.2	0.2	0	0
	U_{14} The enterprises' credit	0	0.6	0.4	0	0
	U_{15} Enterprise development prospect	0.2	0.2	0.6	0	0
U2 The business structure and production capacity evaluation	U_{21} Technical cooperation	0.8	0.2	0	0	0
	U_{22} Personnel situation	0.2	0.8	0	0	0
	U_{23} Financial condition	0	0.4	0.6	0	0
	U_{24} Equipment condition	0	0.4	0.6	0	0
	U_{25} Production condition	0	0.2	0.6	0.2	0
U3 Quality evaluation system	U_{31} Quality system	0.8	0.2	0	0	0
	U_{32} Quality in the product development	0.6	0.4	0	0	0
	U_{33} Quality of supply	1	0	0	0	0
	U_{34} Quality inspection and testing	0.2	0.8	0	0	0
U4 Enterprise environment evaluation	U_{41} Political and legal environment	0.2	0.6	0.2	0	0
	U_{42} Economic and technological environment	0.6	0.4	0	0	0
	U_{43} Natural geographical environment	0	0.2	0.2	0.6	0
	U_{44} Social and cultural environment	0	1	0	0	0

136.4.3 The Operations of Fuzzy Comprehensive Evaluation

First seek the final comments of U1, U2, U3, U4: $B_i = U_i \circ R_i$, among them, U_i is weight vector of each son factors under the U_i,"$\circ$" is the operator of fuzzy operators. Because of the factors of influence the comments are very much, in order to avoid the loss of valuable information, and do the real objective and fair, we should take into account various factors, so we use the weighted average method, namely use the fuzzy operator of the operators M = (*, +), so we regard

U_i as a single element, and use B_i as single factor evaluation vector of U_i, we may constitute a fuzzy evaluation matrix from U to V (Wang and Yu 2007).

$$\mathrm{R} = \begin{pmatrix} B1 \\ \vdots \\ Bs \end{pmatrix} = \begin{pmatrix} b11 & \ldots & b1m \\ \vdots & & \vdots \\ bs1 & \ldots & bsm \end{pmatrix}$$

Calculate B = U ∘ R, among them U is a vector that made up of weight of U_1, U2, U3, U4, according to the maximum membership degree (namely select the the biggest value corresponding comments as general evaluation), we can come to a conclusion of real estate supply chain partner of an overall evaluation, they respectively belong to good, better, medium, a little poor and poor (Kwon et al. 2007).

By weights,

U = (0.53, 0.01, 0.29, 0.08)

U1 = (0.03, 0.09, 0.43, 0.05, 0.26)

U2 = (0.35, 0.13, 0.20, 0.18, 0.14)

U3 = (0.02, 0.14, 0.18, 0.24)

U4 = (0.32, 0.20, 0.23, 0.17)

From the formula $B_i = U_i \circ R_i$, the calculation is:

B1 = (0.358 0.346 0.268 0.028 0)

B2 = (0.306 0.354 0.312 0.028 0)

B3 = (0.368 0.460 0.168 0.004 0)

B4 = (0.184 0.568 0.110 0.138 0)

From the formula B = U ∘ R,

$$\mathrm{R} = \begin{pmatrix} B1 \\ B2 \\ B3 \\ B4 \end{pmatrix} = \begin{pmatrix} 0.358 & 0.346 & 0.268 & 0.028 & 0 \\ 0.306 & 0.354 & 0.312 & 0.028 & 0 \\ 0.368 & 0.460 & 0.168 & 0.004 & 0 \\ 0.184 & 0.568 & 0.110 & 0.138 & 0 \end{pmatrix}$$

B_{Alan} = (0.3418 0.3976 0.2308 0.0298 0), according to the maximum membership degree theory, Alan's final evaluation is better.

Similarly, we can obtain the final evaluation results of the other two engineering general contractors, that is B_{Jack} = (0.3406 0.4838 0.1550 0.0186 0); B_{Mike} = (0.2306 0.3396 0.4230 0.0325 0.0013). According to the maximum membership degree theory, the final assessment of Jack is better, and the final assessment of Mike is medium.

136.4.4 The Set of the General Contractor

The paper above has do the rank evaluation to general contractor with the fuzzy comprehensive evaluation method, because comments set V = {good, better, medium, a little poor, poor} gives some qualitative values, it's not convenient to compare the superior and inferior of each general contractor directly (Zhu et al. 2007). For the convenience of comparison, we can give these qualitative value a series of corresponding provisions quantitative values according to the experience, we hypothesis that there were t real estate supply chain partners are compared, the last comprehensive score of the pth partner is $\mathrm{W_p} = \sum_{k=1}^{m} \mathrm{b_{pk} y_k}$. In the formula, b_{pk} is final comprehensive scores of the kth comments of pth partner, through the calculation of W_p, we can compare comprehensive level of t real estate supply chain partners, the greater value the W_p is, the partners' comprehensive evaluation is higher.

In this example, we determine $\mathrm{V} = \{100, 80, 60, 40, 20\}$ and in comments, we can calculate it through the calculation, $\mathrm{W_{Alan}} = 0.3418{*}100 + 0.3976{*}80 + 0.2308{*}60 + 0.0298{*}40 = 81.03$; $\mathrm{W_{Jack}} = 0.3406{*}100 + 0.4838{*}80 + 0.1550{*}60 + 0.0186{*}40 = 82.90$; $\mathrm{W_{Mike}} = 0.2306{*}100 + 0.3396{*}80 + 0.4230{*}60 + 0.0325{*}40 + 0.0013{*}20 = 74.23$.

We can know that Jack is the highest rated. Therefore, we suggest the real estate development enterprises choose the total engineering contractor Jack as a supply chain partner's enterprise.

136.5 Conclusion

The fuzzy comprehensive evaluation method provides a kind of analysis of complex object in the angle of levels, on one hand, it complies with conditions of reality system, and is good for objectively describing the evaluated objects maximum (Croom 2000). On the other hand, it's good for as accurate as possible to determine the weight. When we determine the weight from factors on the important degree of the evaluated object, we always look the weight of whole evaluation factors' system as the whole "1", like this, when complex system contains more evaluation factors, inevitably the weight of each factor is very close, the difference of important degree between factors will not easy to reflect. But if complex system layered, each factors of the level will be less, and factors for the evaluated object's membership and important degree would be easier to determine. Therefore, the more complex the evaluated object is, and the more structure level is, the effect is more ideal with multi-level fuzzy comprehensive evaluation.

With the example above we can be see that this model not only can comprehensively evaluate and choose for a single real estate supply chain partners, but also can be used to comprehensively sort and analyze for more real estate supply chain partners competitive advantage (Beamon 1998).

The fuzzy comprehensive evaluation method's adaptability is strong, it can not only be used to comprehensive evaluation of subjective factors, but also be used to comprehensive evaluation of objective factors. In the practical life, the fuzzy phenomena of "also this also that" massively exist (Masuchun et al. 2006), so the application of fuzzy comprehensive evaluation's range is very wide, especially in the comprehensive evaluation of subjective factors, because the fuzziness of subjective factors is very large, using fuzzy comprehensive evaluation can play to the advantages of the fuzzy method, and the evaluation effect is better than other methods.

Establishing the real estate enterprise supply chain partner relationship is focus of real estate enterprise supply chain's strategy management, and also is the core of the real estate enterprise supply chain management. Real estate supply chain partner relationship is a kind of long-term stability, trust and cooperation win–win strategy alliance that setting up on the basic of Real estate development project with the resources advantage of supply chain enterprise core competitiveness and integration. Benefiting before real estate enterprises' implementation of supply chain strategy cooperation relationship (Mathews et al. 1996),we should know the supply chain's establishment of cooperation is the change of the structure of the enterprise, so we should choose the supply chain partners carefully, and ensure supply chain cooperation relations and the realization of the interests of the enterprises.

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In the process of writing this article, I refer to a large number of literature, and lessons from some of these views, and I have detailed in the reference list, here expresses our heartfelt gratitude to the authors of the literature.

Sincerely thanks each expert and professor for reviewing my paper in spite of being very busy to glance.

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Chapter 137
The Research of Inventory Management Modes Based on Supply Chain Management

Kai Wang

Abstract Based on the environment of supply chain management and in the premise of full consideration of the complexities and particularity of different supply chain inventory types, this paper researches different supply chain inventory management modes, and discusses the appropriate application environment of each inventory management mode. At the same time, it also analyses the core ideas and implementing strategies of all sorts of inventory management mode, which show how to correctly use these inventory control modes and demonstrate the different inventory control programs of different inventory management modes. Finally, this paper also gives the integral operation framework of these inventory management modes to analyze the implementing measures and solution approaches of each inventory management mode, which makes these inventory modes more intuitive.

Keywords Inventory · Management · Management mode · *S*upply chain

137.1 Introduction

In the supply chain environment, whether the competition among enterprises or the pursuit of the interests of the whole enterprise alliance, directly transforms into the management and optimization of supply chain, and inventory management is an important link of the supply chain management (Zhao 2003; Zhu et al. 2008; Liang 2005) inventory cost is one of the most important part of supply chain cast (30 % or more) (Yu 2004; Liao 2006), so the research of inventory management mode is extremely significant to promote the overall performance of the supply chain

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(Qin 2007; Fang 2004; Li 2008) This article analyses and researches three general structures of the supply chain inventory management modes (one-echelon, two-echelon and multi-echelon inventory) (Yun 2008; Liu 2011a; Cui 2007a).

137.2 One-Echelon Inventory Management Mode

One-echelon inventory control mode essentially is node enterprises' own inventory management, is the control and management strategy of enterprise inventory. For the research of one-echelon inventory control mode is generally based on the condition that the supply chain is shorter and the external influence to enterprise is relatively small. In this environment of supply chain, this inventory management mode is based on the minimum of respective inventory cost, and the external information needed to be considered is relatively few.

One-echelon inventory control mode of node enterprises in the supply chain can be divided into two kinds: one kind is definite type of storage mode, parameters of which are not changed in every order cycle, or the average of parameters can be got through seeking average value. Another one is the random type of inventory mode, some parameters of which are uncertain variables (Bowersox and Closs 1996; Dong 2002; Cheung and Lee 2002). Definite types of storage mode has five types that is instantaneous stock and no shortage of stock, instantaneous stock and allowance of the shortage of stock (Chun 2007), non-instantaneous stock and allowance of the shortage of stock, purchase price decided according to bulk discounts, and multispecies storage mode; Random type of inventory mode is including the single phase storage mode in which the demand is discrete random variable, and the storage mode in which the demand is continuous random variable (Liu 2011b; Xian 2006). The most common is the order mode in which demand is time-varying functions and not allowed the shortage of stock, and it is a sale order inventory mode of deterioration economy without shortage of stock based on the linear variation of price according to the demand change and the situation in which inventory has influence to sale (Zhu 2004; Dai 2007; Li 2009).

137.3 Two-Echelon Inventory Management Mode

In the complex supply chain environment, because of the inventory management strategy that each of supply chain members ignores the interests of the other members, information distortion phenomenon which so-called ''The bullwhip effect'' appears during transmission of the supply chain. In order to improve the performance of the whole supply chain operation, Vendor Managed Inventory (VMI) and Jointly Managed Inventory (JMI) have been produced and improved (Li 2008; Cui 2007b; Ding and Zhang 2000).

137.3.1 Vendor Managed Inventory

Vendor Managed Inventory (VMI) is a kind of cooperation strategy between the customer and supplier, makes both sides realize the lowest cost, in a mutually agreed framework of the target, inventory is managed by the Vendor, and such target framework is often regularly supervised and corrected to produce a continuous improvement environment. VMI emphasizes on the decision-making agent mode of integrated operation in the supply chain with the prerequisite of the lowest cost of both supplier and demander available, and in the relevant framework of jointly formulated agreement, supplier agents inventory decision-making, the suppliers fully perform the inventory decision-making authority of distributors or wholesalers, and at the same time both sides jointly supervise and correct the framework to achieve the common inventory goal.

VMI as an advanced inventory management mode have achieved the zero-inventory of the downstream enterprises, and also propels the circulation of the supply chain information among the node members. Specific implementation includes the following contents, as shown in Fig. 137.1.

(1) Establishing customer intelligence information system. Suppliers do inventory decision-making for the downstream customers and should inevitably get the full market demand information of the downstream customers, so market demand information database must be established. Suppliers keep track of market demand change, put the market information of downstream customers to the information database, and collect the demand forecasting and market analysis of the customers to the database.

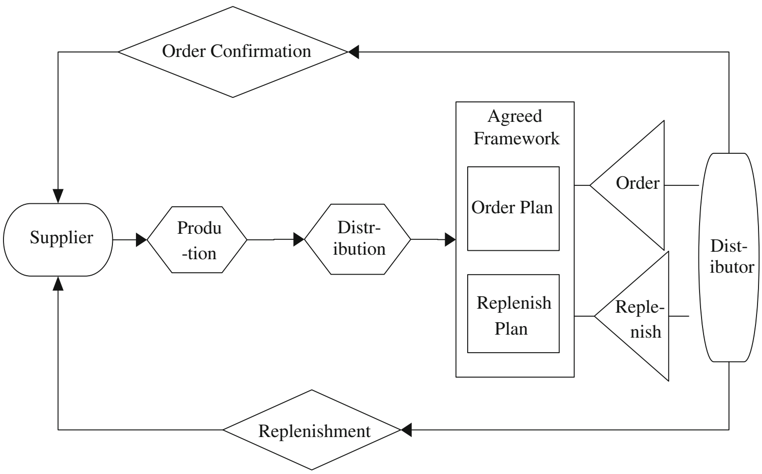

Fig. 137.1 VMI operation framework

(2) Establishing logistics network management system. Perfect logistics network is beneficial to the logistics flow between upstream and downstream enterprises, and advanced hardware and software system is crucial to improve logistics network performance. At present, the wide application of the MRP and ERP integrates the existing logistics functions, and the expansion of these functions can make the logistics network system more perfectly.
(3) Establishing a cooperation agreement framework. Such cooperation strategy of suppliers and customers is completed through setting the common target framework, so both parties must work together to make the cooperation agreement framework, at the same time, both sides ascertain the business process of order processing and the related parameters of inventory control through consultations.
(4) Organizing structure reforming or business restructuring. VMI cooperation mode changes the original inventory management mode and inverts the original responsibility, and suppliers have added a new function, so relevant organizations also need to add new functions after adjusting.

137.3.2 Jointly Managed Inventory

Because of the existing VMI shortcomings, jointly managed inventory (JMI) is produced. JMI is a kind of inventory management mode based on the development of VMI, and emphasizes on the parity of authority and responsibility and the sharing of risk, reflects the new type of alliance cooperation relationship in the supply chain. Jointly managed inventory is to solve the variation amplification phenomenon of information brought by independent inventory of node enterprises in the supply chain, and emphasizes the coordination function of node enterprises. Jointly managed inventory is to solve the variation amplification phenomenon of information brought by independent inventory of node enterprises in the supply chain. In the jointly making of inventory planning process, node members of supply chain should consider from mutual coordination to keep demand forecasting of each node inventory consistent, so as to eliminate the differences of information. The implement strategy of jointly managed inventory is as following, the conceptive operation framework is as shown in Fig. 137.2.

(1) Establishing a coordination management mechanism of supply chain. In order to give full play to inventory management advantages of each node member in the supply chain, each member should actively establish effective cooperation mechanism, and members can be in view of the following aspects: (1) Setting the common optimal goals. (2) Making coordination control methods of joint inventory. (3) Creating support system of information sharing. (4) Establishing effective distribution of interests and incentive mechanism.
(2) Establishing a perfect information support system and logistics management system. Getting the market information and giving a rapid response to this

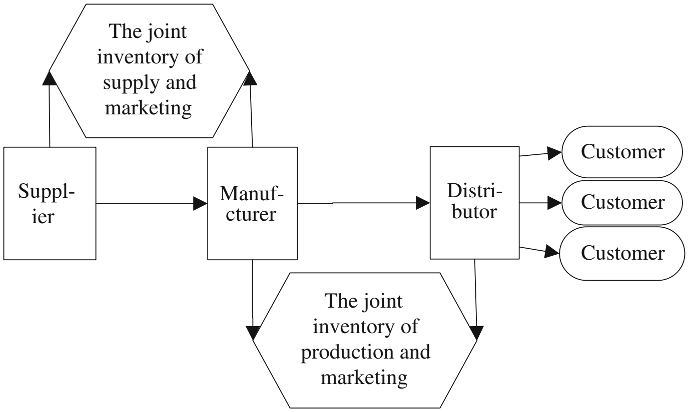

Fig. 137.2 JMI operation framework

information is very important to give full play to JMI. On the basis of EDI platform or electronic commerce of node enterprises in the supply chain, cooperative enterprises jointly integrate barcode technology, POS system and order automatic processing system. And reducing the cost in these aspects such as supply system management, confirmed ordering, delivery time interval and so on, to eliminate the delay of the handover between supply and demand. The application of the mature technology is also an effective way to improve the performance of this management mode, MRP and ERP are relatively mature logistics management systems, which strengthen the coordination and cooperation in the supply chain.

(3) Giving full play to the third party logistics system. The third party logistics is a key technology and method of supply chain management. In the JMI, both sides of supply and demand revoke the inventory with the aid of the third party logistics, both parties contact directly with the third party logistics system, which reduces the burden on the function and increases the agility and coordination of the supply chain. Moreover, the third party logistics provides services including product transportation, the choice and buy of orders, inventory level, and so on, and establish a bridge for suppliers and customers.

(4) Choosing appropriate JMI mode. The existing JMI modes include: (1) Suppliers' parts are directly deposited to the raw material inventory of core enterprise, the dispersion inventory of each supplier inventory changes into concentration inventory of core enterprise. (2) Non-inventory management mode in which suppliers and the core enterprise don't establish inventory, the core enterprise does production with no inventory. Choosing the right JMI mode is beneficial to develop the biggest function of JMI.

137.4 Multi-Echelon Inventory Management Mode

The more complex supply chain structure is, the more inventory echelon has, and the whole supply chain management has more challenges. Multi-echelon Inventory Control Optimization and Collaborative Planning, Forecasting and Replenishment (CPFR) provide effective strategy for multi-echelon inventory management (Yan and Lu 2003; Guo 2009).

137.4.1 Multi-Echelon Inventory Control Optimization

The ultimate purpose of the supply chain inventory management is to make inventory cost of all stages in the whole supply chain minimum, and the current management mode of enterprise inventory is separate, which cannot make the whole supply chain optimal. Therefore, it is necessary to control and optimize multi-echelon inventory, it is inventory management technology to integrate global resources under the supply chain management environment.

(1) The considered problems of multi-echelon inventory optimization

   (a) The control optimization goals. The traditional inventory control optimization targets on the cost optimization, but with the development of the economy, more and more enterprises pay attention to the optimization of the time, time also become some enterprises' goal of optimization control.
   (b) The clear scope of the control optimization. As a part of the supply chain management, inventory management is divided into local inventory management and integral inventory management. In a complex supply chain organization system, enterprises must clearly know what kind the inventory management is, namely to clearly confirm the scope of inventory control optimization.
   (c) Confirming the exact inventory control strategy. In a enterprise with separate inventory, the enterprise generally uses the periodic inspection and continuous checking, these two kinds of inventory strategy are still applicable in multi-echelon inventory, the inventory checking of node enterprises is no longer their own inventory checking but as a inventory state of supply chain inventory system, which is the judgment basis of supply chain inventory state and affect the entire supply chain inventory level.
   (d) The effect of control optimization. In the implementation of the multi-echelon inventory control, the specific management functions are directly handed over to all members of the supply chain organization, so the effect has a certain distance from the designed expectations. Since the simple multi-echelon inventory management does not produce good optimization result, supply chain members and the management means must be optimized, then the control optimization strategies can be achieved the expected effect.

(2) The methods of multi-echelon inventory control optimization

Multi-echelon inventory control optimization has two methods. One kind is distributed strategy, this strategy is that all inventory points make decision independently for their own inventory, which is relatively simple in the entire supply chain management and does not guarantee the production of the whole supply chain optimization. This strategy can't make effective information sharing and only can get the result of the second best. Therefore, distributed strategy needs to build information sharing channel. The other is centralized strategy, in which control center has priority over the core enterprise, the core enterprise control the inventory of the whole supply chain system and coordinate inventory activities of upstream and downstream members in the supply chain, so as to minimize the supply chain inventory cost. In the centralized inventory system, the inventory control strategy is echelon control, each inventory point is no longer only an independent inventory but as a certain level inventory in the supply chain environment. But the management of centralized strategy is difficult, especially the multi-echelon supply, which increases the difficulty of the coordination and control, centralized strategy operation framework is as shown in Fig. 137.3.

137.4.2 *Collaborative Planning, Forecasting and Replenishment (CPFR)*

Collaborative Planning, Forecasting and Replenishment (CPFR) is a kind of collaborative management technology of supply chain inventory, it is sponsored by Wal-Mart and its five suppliers that is Warer-Lambert, SAP, Manugistics and Benchmarking, to eventually reduce sellers' inventory quantity and increase

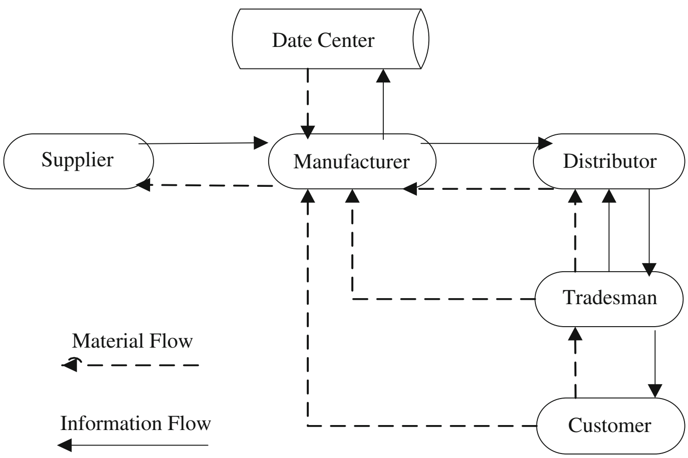

Fig. 137.3 Operation framework of centralized inventory control strategy

suppliers' sales. The biggest advantage of CPFR is which can prompt and accurately predict the fluctuation and trend of the sales brought by the sales promotion means and changes, so that each node enterprise of supply chain can be fully ready to cope with changes. CPFR fully consider the "win–win" principle, and giving consideration to other aspects of supply chain management based on the core of inventory management.

CPFR applies a series of management measures involving the whole supply chain cooperation process, and manages supply chain through information sharing to improve cooperation relationship of suppliers and retailers to achieve the consistency of the forecast on demand and sales. The core idea is reflected in following: (1) Operation rules framework is mainly based on the needs of consumers and the increase of the whole value chain. (2) The production plan or sales plan of the supply chain members are based on the same demand forecast. (3) Eliminating the flexibility constraint to release the manufacturers' pressure brought by the changes of production plan.

The steps widely used in current inventory management of CPFR have 9, as shown in Fig. 137.4.

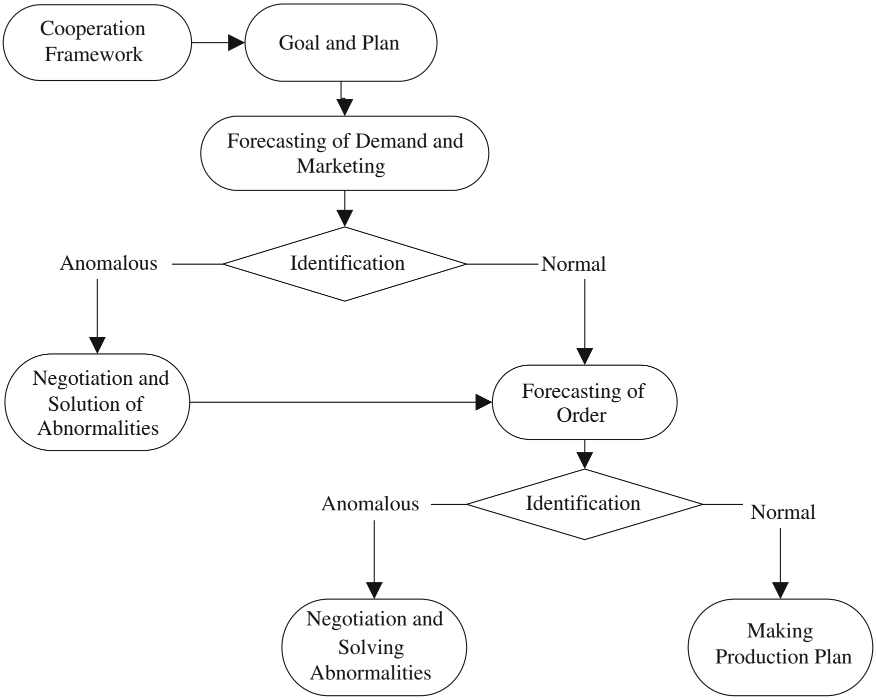

Fig. 137.4 Operation framework of CPFR

(1) Making agreement framework. The expectancy of the framework members, actions and resources needed to ensure successful, cooperative purpose, confidential agreement, and the authorized of resource utilization is within the content of framework agreement, at the same time, the duties of parties and the performance evaluation methods are specified, expounding that members cooperation and information sharing should be strengthened to achieve the cooperation goals and the risk needed to assume.
(2) Making the business plan. In the process of program formulation, distributors and manufacturers exchange the respective information of company development plan each other to jointly make business development plan. In the premise of sharing information, cooperation parties should establish a cooperatively strategic relationship, and define the department responsibilities, goals, and strategies. Scheme contains the minimum product quantity and odds of each order, the lead time and so on.
(3) The forecast of demand and sales. Under the help of the real-time and historical data information, partners make demand and sales forecast, both sides will collect respective forecast, and consult to make satisfactory forecast.
(4) Identifying prediction abnormalities. According to the identification standard, cooperation enterprises check and audit every item of the prediction and finally draw abnormal item list.
(5) Negotiating to solve abnormalities. Cooperation members review and negotiate the abnormal items, and then updated forecast report to make the forecast report more accurate. Such prior inspection is beneficial to reduce the mistakes and risk, as well as to strengthen the communication between partners.
(6) Order forecast. Partners make order prediction under the help of the real-time and historical data, which include sales data, inventory data and other data relevant the generation of order forecast. The actual order information is changing with time, so short-term report is the production plan of a period, long-term report is a plan for future production. Order forecast report is beneficial to manufacturers make production plan in time and offer production to the seller or wholesalers in time, which also makes the vendors have enough goods.
(7) Identifying prediction abnormalities. According to the limit or standards of items, parties check and audit the content of the prediction to determine which items are beyond the standard.
(8) Negotiating to solve abnormalities. Partners negotiate to solve abnormal contents.
(9) The generation of production plan. Enterprises transform predicted order into production plan, and replenish inventory and sell marketing inventory. The production plan can be completed by distributors or manufacturers, which depends on their duties and resources situation.

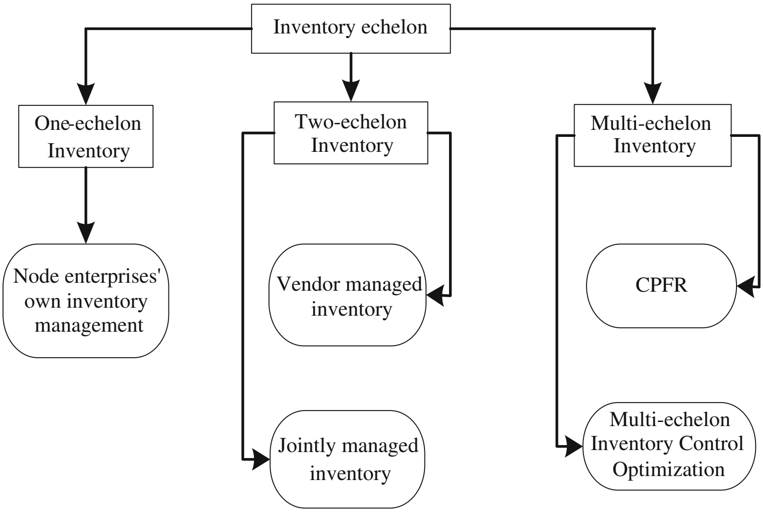

Fig. 137.5 Inventory management modes

137.5 Conclusion

(1) According to the research of research of inventory management modes, we can conclude the appropriate application environment of each inventory management mode, as shown in Fig. 137.5.
(2) Different inventory management modes have different inventory control programs, and has specific application environment, so before choosing inventory management mode, we should considerate the complexities and particularity of different supply chain environment.

As the changing of supply chain environment day by day, inventory management modes also adapt to the development. According to the structure of supply chain, cooperative alliances select the appropriate inventory management mode is very important to reduce the inventory cost and increase the value of the value chain. All kinds of inventory management strategy have their own advantages and disadvantages, only through fully surveying and analyzing actual requirement to select the reasonable supply chain application environment, can the inventory management modes play their biggest function to promote the value of the value chain.

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Chapter 138
The Study of Decision-Making Mechanism of Knowledge Sharing in Supply Chain Enterprises

Liang Ye and Guo-fang Song

Abstract Knowledge sharing is an important mean of the enterprises to acquire competitive advantage in the supply chain enterprises. This paper analyzes the type of knowledge in the supply chain, and points out that the cause of the flow of knowledge is the difference of knowledge between organizations. Through building the knowledge sharing model of enterprises in the supply chain, this paper confirms that the effective knowledge sharing can promote supply chain enterprise income, and reveals the dynamic mechanism and decision-making conditions of the supply chain enterprises' participating in the knowledge sharing.

Keywords Decision-making supply chain · Knowledge sharing · Game model

138.1 Introduction

With the global economic integration and rapid development of information technology, the competition among individual firms is gradually being replaced by the rival of supply chains. Seeking the advantage of the supply chain is a major approach for a modern enterprise to establish the core competitiveness. So the knowledge of the supply chain has become an important asset of each node enterprise.

At present, the related research of the supply chain knowledge sharing mainly carried out around the knowledge sharing mechanism, the knowledge sharing impact factors, the knowledge sharing cooperation conditions and realization ways of knowledge sharing. Through the establishment of the game model of knowledge sharing in supply chain.

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This paper simulates the game process of suppliers and manufacturers in knowledge sharing, analyses in depth the economic characteristics of the enterprises that participate in knowledge sharing in supply chain, and then reveals the dynamic mechanism and decision-making conditions of enterprises in knowledge sharing.

138.2 The Conduct of Knowledge on Supply Chain

The knowledge on the supply chain enterprise exists not only within the enterprise, but also in companies, involving various knowledge of different subject. From the perspective of the enterprise value chain, the knowledge management activities of the supply chain can be seen as the production of raw materials from suppliers to service the whole process of knowledge transformation, integration and dissemination activities (Zhou and Li 2003). Knowledge sharing success depends on the knowledge provider's ability to communicate and the absorptive capacity of the knowledge recipient (Nonaka 1994).

Due to the difference in the amount and structure of knowledge, any knowledge main bodies of the supply chain is always not unsymmetrical. So there are knowledge gap between them, just like water flow and heat transfer. Since knowledge always flows from the high potential energy to the low potential energy, the same thing will occur in the supply chain.

The effective knowledge sharing in supply chain can improve rapid response capability of the whole supply chain, reduce the costs of production and operation, and enhance overall competitiveness of the supply chain.

138.3 Knowledge Sharing on Supply Chain

Knowledge sharing is an interaction of knowledge produced through four processes of knowledge, which are mutual change, externalization, combination and internalization (van den Bart and Ridder 2004), and is also a process of the exchange of knowledge between individuals and jointly create new knowledge (Davenport and Prusak 1998). Knowledge sharing success depends on the knowledge provider's ability to communicate and the absorptive capacity of the knowledge recipient (Zhang and Chen 2004). The effective knowledge sharing in supply chain can improve rapid response capability of the whole supply chain, reduce the costs of production and operation, and enhance overall competitiveness of the supply chain.

138.3.1 The Basic Model and Assumptions

In order to simplify the analysis, we consider only a single product supply chain which contains only a supplier and a manufacturer (Weng and Zhong 2008). The Stackelberg game model is studied, in which the supplier S is the core business and the manufacturer M is the node enterprise.

First, assume that the suppliers produce the intermediate products in the unit cost of CS, and provide all the products to manufacturers with the transfer pricing PS; manufacturers with the unit cost CM production for re-processing, and eventually sale the finished product to market with the retail price PM. Let inverse demand function be defined as PM = a-bQ, in which Q is market demand, a, $b > 0$, $Q \leq a/b$.

Second, the unit cost decreases along with the amount of sharing knowledge absorbing from the other enterprises increases (Weng and Zhong 2008). Assuming the unit cost function like $CS = A\text{-}RS\Delta XM$, $CM = B\text{-}RM\Delta XS$, where $0 < A < B < a$, RS and RM refer to the ability of absorption and transformation of S and M respectively (RS, RM > 0), ΔXS and ΔXM refer to the amount of shared knowledge of S and M transferred to the other respectively (ΔXS, ΔXM ≥ 0). Be noted that: (1) Unit production cost function don't have to be linear, but need to meet $C'(\Delta X) < 0$, namely the unit production cost increases along with the amount of shared knowledge is reduced. (2) When the unit cost of production achieved a fixed value, the increase in the amount of shared knowledge and the promotion of ability of absorption and transformation of knowledge will no longer cause unit production cost reduction. In order to facilitate analysis, the simplified linear function is adopted.

Third, assuming that the cost of S and M using knowledge-sharing strategy is LSΔXS and LMΔXM, respectively. Where LS and LM are risk factors, and refer to the level of risk bringing from S and M taking sharing strategy respectively.

Based on the above assumptions, we can get the target profit function πS and πM of S and M, respectively.

$$\pi S = (PS - CS)Q - LS\Delta XS = (PS - A + RS\Delta XM)Q - LS\Delta XS \tag{138.1}$$

$$\begin{aligned} \pi M &= (PM - PS - CM)Q - LM\Delta XM \\ &= (a - bQ - PS - B + RM\Delta XS)Q - LMHXM \end{aligned} \tag{138.2}$$

138.3.2 Model Analysis

In view of the supply chain between enterprises already exists the cooperation relationship; member enterprises relatively understand each other's strategic space, payoff function and the value of the sharing knowledge. So ignored a number of other uncertainty factors, we can assume that the knowledge sharing behavior between enterprises in the supply chain is a complete information dynamic game process.

The decision-making process of knowledge sharing Stackelberg model in supply chain is divided into two phases. First, the supplier S choose their own transfer pricing P_S and the amount of shared knowledge ΔX_S according to their principle of profit maximization. Then the manufacturer M choose their own optimal order quantity Q and the amount of shared knowledge ΔX_M according to their own profit maximization principle. The comparison of knowledge sharing behavior between upstream and downstream enterprises in the supply chain give bellow in both cases: (1) without knowledge sharing between the supplier S and the manufacturer M; (2) knowledge sharing between the supplier S and the manufacturer M.

(1) Without knowledge sharing

In this case, $\Delta X_S = 0$, $\Delta X_M = 0$. According to the game solution of the backward induction, we first analyze the second stage of game. The manufacturer M choose their own optimal order quantity Q according to their own profit maximization principle and the problem of the manufacturer M is max $\pi_M(Q, P_S) = (P_M\text{-}P_S\text{-}C_M)Q = (a\text{-}bQ\text{-}P_S\text{-}B)Q$. The optimization of the first-order conditions is $d\pi_M/d_Q = 0$, then you can have:

$$Q(P_S) = \frac{a - B - P_S}{2b} \tag{138.3}$$

The supplier S forecasts that the manufacturer M will select the Q based on Q (P_S), and the problem of the supplier S in the first phase is:

$$\text{Max } \pi_S(P_S, Q(P_S)) = (P_S - A)Q(P_S) \tag{138.4}$$

Then substitute (138.3) for $Q(P_S)$ in (138.4) and solve the optimization of the first-order conditions $d\pi_S/dP_S = 0$. The optimal transfer price of the supplier S is got: $P_S^* = \frac{a+A-B}{2}$. So we can get: $Q^* = \frac{a-A-B}{4b}$, $P_M^* = \frac{3a+A+B}{4}$, $\pi_S^* = \frac{(a-A-B)^2}{8b}$, $\pi_M^* = \frac{(a-A-B)^2}{16b}$.

(2) Knowledge sharing

According to the dynamic game solution of the backward induction, we first analyze the second stage of game. The manufacturer M choose their own optimal order quantity Q and the amount of shared knowledge ΔX_M according to their own profit maximization principle and the problem of the manufacturer M is:

$$\text{Max } \pi_M(Q, P_S, \Delta X_S, \Delta X_M) = (a - bQ - P_S - B + R_M \Delta X_S)Q - L_M \Delta X_M \tag{138.5}$$

The optimization of the first-order conditions is $d\pi_M/d_Q = 0$, then you can have:

$$Q(P_S) = \frac{a - B - P_S + R_M \Delta X_S}{2b} \tag{138.6}$$

Then substitute (138.6) for Q (P_S) in (138.5). And the target profit function of the manufacturer M is got:

$$\pi_M(P_S, \Delta X_S, \Delta X_M) = \frac{(a - B - P_S + R_M \Delta X_S)^2}{4b} - L_M \Delta X_M \tag{138.7}$$

The manufacturer M choose the amount of shared knowledge ΔX_M to the supplier S according to their own profit maximization principle. By (138.6), we know that when the supplier S have given P_S and ΔX_S, the manufacturer M's profit function π_M is a decreasing function of ΔX_M. Therefore, the results of the Nash equilibrium is $\Delta X_M = 0$, that is the amount of shared knowledge of the manufacturer M is zero and the manufacturer M acquire the biggest profit.

The supplier S forecasts that the manufacturer M will select the Q based on Q (P_S) and $\Delta X_M = 0$, so the problem of the supplier S in the first phase is:

$$\text{Max } \pi_S(P_S, Q(P_S), \Delta X_M) = (P_S - A)Q(P_S) - L_S \Delta X_S \tag{138.8}$$

Then substitute (138.6) for Q (PS) in (138.8) and solve the optimization of the first-order conditions $d\pi S/dPS = 0$. The optimal transfer price of the supplier S is got:

$$P_S^{**} = \frac{a + A - B + R_M \Delta X_S}{2}.\ Q^{**} = \frac{a - A - B + R_M \Delta X_S}{4b}$$

So we can get:

$P_M^{**} = \frac{3a+A+B-R_M\Delta X_S}{4}$, $\pi_M^{**} = \frac{(a-A-B+R_M\Delta X_S)^2}{16b}$, and the maximum profit for the supplier is:

$$\pi_S^{**} = \frac{(a - A - B + R_M \Delta X_S)^2}{8b} - L_S \Delta X_S$$

when $d\pi S/d\Delta XS > 0$, the profit function of the supplier S is an increasing function of ΔXS, and the solution is:

$$\Delta X_S > \frac{4bLs - (a - A - B)R_M}{R_M^2} \tag{138.9}$$

Let $M = \frac{4bLs-(a-A-B)R_M}{R_M^2}$. The M value means the critical point that the amount of transferred knowledge impact on the profit and the size of M is relative to RM and LS. When $\Delta X_S > M$, ΔX_S and π_S has the positive correlation; conversely, has a negative correlation. The greater of the value of M indicates that the supplier S needs to transfer more knowledge to the manufacturer M to make the revenue sharing to make up for sharing costs. Therefore, the supplier S needs to reduce the critical point of the sharing knowledge, that means the value of M as small as possible, you need to improve RM, reduce LS.

By comparing two parts we can see: $Q^{**} > Q^{*}$, $PM^{**} < PM^{*}$. This means that through knowledge sharing between enterprises can improve the technical level, improve product quality, thus to facilitate the expansion of the market demand and the retail prices drop. Of course, the role of Q and P to the corporate profits also affect by the influence of b. According to the theory of economics, when the price elasticity of demand $1/b > 1$, the demand is rich in elasticity, and the profits increase when the product prices decline. So, the more demand elasticity of the goods, the additional revenue gained by reducing costs in the process of sharing knowledge is greater.

138.4 Conclusion

The results of knowledge sharing in supply chain depend on the degree of joint efforts of all members in the process of sharing (Saxena and Wadhwa 2009). Improve the knowledge communication ability and knowledge absorptive capacity of supply chain enterprise can promote enterprise management efficiency. Thereby knowledge sharing can bring the extra income for enterprises (Lin 2007). Based on the model analysis, the strategy of knowledge sharing in supply chain is put forward as follows: (1) to set up reasonable risk-sharing and profit sharing distribution mechanism, supply chain enterprises can not only get the income, but also bear the cost of the spread of knowledge during the sharing process (Lee et al. 2005). In order to make knowledge flow orderly in supply chain, the knowledge sharing revenue should be improved of every supply chain nodes (Siemsen et al. 2008). And the cost-sharing and revenue-sharing is the important principles to share nodes' knowledge; (2) The more demand elasticity of the goods, the additional revenue gained by reducing costs in the process of sharing knowledge is greater; (3) To reduce the risk of inter-enterprise knowledge sharing, knowledge sharing will bring about risk to supply chain enterprise (Chen and Chen 2006), such as decision-making risk, moral risk, knowledge spillovers risk and distribution risk. In order to reduce risk the cost of knowledge sharing, it should be the effective means that to perfect the knowledge sharing risk and control mechanism; (4) to enhance the ability of absorption and transformation of knowledge of enterprise. It can reduce the condition of knowledge sharing and improve the motivation of participating in the knowledge sharing.

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Chapter 139
The Time-Based Order Decision-Making in the Supply Chain with the Nonlinear Lead Time Cost

Jiang-tao Wang, Jian-jun Yu and Hua Bai

Abstract Differencing with the general literatures on lead time, the time-based order decision-making problems in supply chain are considered in this paper. The time-variant variance of the market demand is embedded into modeling the order decision-making on order time for the retailer. By using the nonlinear lead time cost, we can overcome the scenario faced by given literatures where the optimal order time or lead time for the supply chain members always exists in the interval endpoint and give a good proof that the QR system in the supply chain is beneficial to each other in supply chain when facing high-risk.

Keywords Lead time · Nonlinear cost · Time-variant · Supply chain

139.1 Introduction

Price and timely delivery are two important factors for success for service providers in today's competitive markets, and many service companies are offering time guarantees as a marketing weapon to attract customers in a time-sensitive market. The market demand are of great complex with the emergence of the short-cycle and seasonal products. In order to make sure the market demand, the lead time are attracting more attention. How to enhance the forecast accuracy to obtain

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the available order in time is an interested item in supply chain, especially for these products with long lead time. At present, there is substantial amount of research work that looks at the impact of time performance and price decisions. With the increasing uncertainty of the demand market, the lead time plays an important role in the supply chain. As Schonberger (1982) point out that shorten lead time can reduce safety inventory and stock losses and improve the customer's serve level, finally enhance the competitiveness. Also, shorten lead time can reduce the forecast errors. Hence, many authors consider shorten lead time in inventory or operation management. Liao and Shyu (1991) present the lead time in forms of operation hours to study the shorten time and cost in every interval, and obtain the optimal lead time to minimize the inventory cost. However, some authors study the lead time models from different situation, such as, multi-inventory management, order cost, discount (Ouyang et al. 1996; Moon and Choi 1998; Ouyang et al. 2002; Jason and Yu 2005). Generally, newsvendor model is an important model to consider the order decision-making problems with the given wholesale price and const forecast variance (Walker 1992, 1993). However, the market is dynamic and stochastic based on time. Retailers own more information on the market and can make forecasting more accuracy by updating information. So, Chen and Chuang (2000) present the time-variant variance of market demand and analyze the extended newsvendor model with shortage level constrains. As general, shorten lead time is an effect method to enhance the performance in supply chain. However, it is difficult to obtain the proof in the time-based models with the linear lead time cost. So, based on the time-variant variance of the marked forecast, we consider the time-based decisions-making problems with the non-linear lead time cost and obtain the optimal order time for the retailer.

139.2 Model Descriptions and Analysis

139.2.1 Descriptions

The supply chain presented is composed of one manufacturer and retailer. The manufacturer is MTO and produces the seasonal production. The retailer places orders in advance by forecasting the market, which is stochastic. In order to not lose the sale opportunity, all order must be finished before the sale start. As Blackburn (1999) point out in Wal-Mart's survey, if the product is purchased at the beginning of sales, the demand forecast error is 10 %; if purchase is made in advance 16 weeks, then the demand forecast error is 20 %; if the purchase is made in advance 26 weeks, the demand forecast error is 40 %. So, we adopt the forecast form, which also used in Xiao et al. (2000) and Chen et al. (2008) as follows,

$$X(t) = D + \varepsilon(t),\ 0 < t_0 \le t \le T,$$

where, D is the average market demand, t_0 is the acceptable latest time, $(T - t)$ is the observation time on market. $\varepsilon(t)$, which is forecast error at order time t, follows normal distribution with the mean 0 and variance $(t\sigma/T)^2$. Furthermore, the retail price is exogenous variable and determined by the retail market.

In order to improve the performance of supply chain members, we consider the scenario that shortens lead time to enhance the forecast accuracy, which is similar to the QR system present by Iyer and Bergen (1997) and used (Choi et al. 2006) to study the supply chain management. The details literatures reviewed can be found in Choi and Sethi (2010).

139.2.2 The Benchmarks—the Original Decision-Making Model

Before the implementation of the QR system, retailer, as usually, places the order at the beginning of the production period ($t = T$) with the forecast variance σ, then the optimal order quantity Q can be obtained by the following formula,

$$\begin{aligned}\underset{Q}{Max}\prod\nolimits_r(Q) &= pMin(Q, X_T) - wQ - k(Q - X_T)^+ \\ &= (p - w)Q - (p + k)\sigma\int_{-\infty}^{\frac{Q-D}{\sigma}} F(x)dx\end{aligned}$$

where, w is the wholesale price, k is storage cost. With the following derivative functions:

$$\frac{\partial}{\partial Q}\prod\nolimits_r(Q) = (p - w) - (p + k)F\left(\frac{Q - D}{\sigma}\right) \text{ and}$$
$$\frac{\partial^2}{\partial Q^2}\prod\nolimits_r(Q) = -(p + k)\frac{1}{\sigma}f\left(\frac{Q - D}{\sigma}\right) \leq 0.$$

Hence, we can obtain the optimal order quantity as

$$\overline{Q} = D + \sigma F^{-1}\left(\frac{p - w}{p + k}\right)$$

The manufacturer's decision function is

$$\underset{w}{Min}\prod\nolimits_{M,1}(w) = (w - c)Q,$$

where c is the order cost. Similarly, with the derivative functions,

$$\frac{\partial}{\partial w}\prod\nolimits_{M,1}(w) = D + \sigma F^{-1}\left(\frac{p-w}{p+k}\right) + (w-C)\sigma\frac{-(p+k)}{f\left(\frac{p-w}{p+k}\right)}$$

and $\frac{\partial^2 \prod_{M,1}(w)}{\partial w^2} \leq 0$.

Then, there exits an optimal wholesale price $\overline{w}$, which must satisfy the following equation

$$D + \sigma F^{-1}\left(\frac{p-w}{p+k}\right) - \frac{(w-C)\sigma(p+k)}{f\left(\frac{p-w}{p+k}\right)} = 0$$

139.2.3 The Lead Time Decisions in QR System

The decision-making system with QR: we consider the QR system to reduce the forecast error, which is high when order time at $t = T$. In order to avoid the scenario faced by given literatures that the optimal lead time exits at the interval endpoint, which is contrary to realism. Hence, we adopt the nonlinear lead time cost presented in Chen et al. (2008). Also, the nonlinear cost is consonant with the Diminishing marginal utility. Here, we assume the wholesale price charged with the order time is $w = w_0 t^{-\alpha}$, $0 \leq \alpha \leq 1$ and w_0 satisfies $\overline{w} = w_0 T^{-\alpha}$. Then, the decision function for retailer is following

$$\underset{Q,t}{Max}\prod\nolimits_r(Q,t) = pMin(Q, X_T) - wQ - k(Q - X_T)^+$$

Similarly, the derivative functions are

$$\frac{\partial \prod_r(Q,t)}{\partial Q} = p - w - (p+k)F\left(\frac{Q-D}{t\sigma}T\right)$$

and $\frac{\partial^2 \prod_r(Q,t)}{\partial Q^2} \leq 0$. Then, for given order time t, the optimal order time is

$$\overline{Q} = D + \frac{t\sigma}{T}F^{-1}\left(\frac{p-w}{p+k}\right)$$

with $\overline{Q}$, we rewrite the decision function as follows, $\prod_r\left(\overline{Q}, t\right) = (p - w_0 t^{-\alpha})\left(D + \frac{t\sigma}{T}F^{-1}\left(\frac{p-w_0t^{-\alpha}}{p+k}\right)\right) - (p+k)\frac{t\sigma}{T}\int_{-\infty}^{F^{-1}\left(\frac{p-w_0t^{-\alpha}}{p+k}\right)} F(x)dx$ and with the derivation functions as follows,

$$\frac{\partial \prod_r(\overline{Q},t)}{\partial t} = \alpha w_0 t^{-\alpha-1}\left(D + \frac{t\sigma}{T}F^{-1}\left(\frac{p - w_0 t^{-\alpha}}{p+k}\right)\right) + (p - w_0 t^{-\alpha})\frac{\sigma}{T}F^{-1}\left(\frac{p - w_0 t^{-\alpha}}{p+k}\right) - (p+k)\frac{\sigma}{T}\int_{-\infty}^{F^{-1}\left(\frac{p-w_0t^{-\alpha}}{p+k}\right)} F(x)dx$$

and

$$\frac{\partial^2 \prod_r(\overline{Q},t)}{\partial t^2} \ll D\left(-2\alpha w_0 t^{-\alpha-2} + \theta\frac{t}{T}\frac{p+k}{f\left(\frac{p-w_0t^{-\alpha}}{p+k}\right)}\right)$$

where $\theta = \sigma/D$, and there exist an optimal order time $\widehat{t}$ for retailer when $\theta \le f\left(\frac{p-w_0t^{-\alpha}}{p+k}\right)\frac{2\alpha w_0 t^{-\alpha-2}}{p+k}\frac{T}{t}$. Clearly, the optimal order time $\widehat{t}$, which also must satisfy the following nonlinear function, is between the latest accepted order time t_0 and the earliest order time T,

$$\alpha w_0 t^{-\alpha-1}\left(D + \frac{t\sigma}{T}F^{-1}\left(\frac{p - w_0 t^{-\alpha}}{p+k}\right)\right) + (p - w_0 t^{-\alpha})\cdot \frac{\sigma}{T}F^{-1}\left(\frac{p - w_0 t^{-\alpha}}{p+k}\right) - (p+k)\frac{\sigma}{T}\cdot \int_{-\infty}^{F^{-1}\left(\frac{p-w_0t^{-\alpha}}{p+k}\right)} F(x)dx = 0$$

In additions, the order cost with the order time is $Cost(t) = Ct^{-\beta}$, $0 \le \beta \le 1$ and C satisfies$c = CT^{-\beta}$. Then, the manufacturer's profit function is

$$\prod\nolimits_{M,2} = \left(w - Ct^{-\beta}\right)Q$$

and the supply chain profit is

$$\prod\nolimits_c = \left(p - Ct^{-\beta}\right)Q$$

139.3 Numerical Analysis

139.3.1 Solution of the Specific Model

From the analysis above, we can see that the order decisions-making are dynamic. The optimal decisions in the models derived are all the solutions of the nonlinear equations. As we know, it's difficult to present the analytic solutions for the

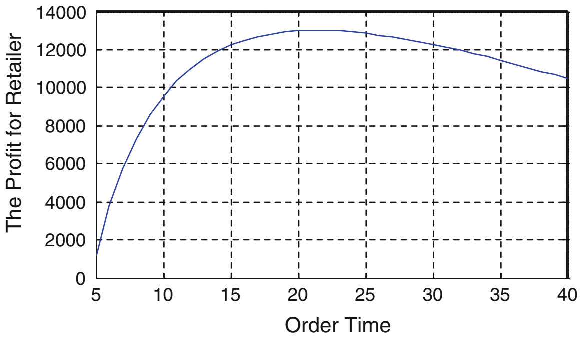


Fig. 139.1 Profit of retailer for order time

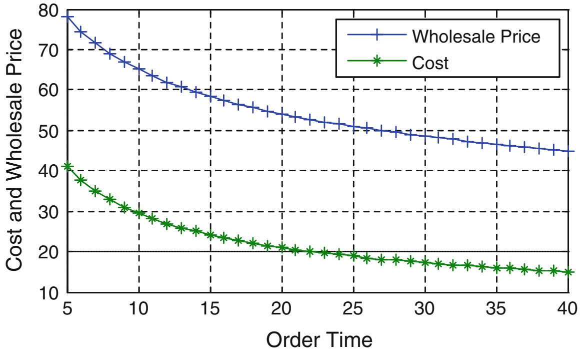


Fig. 139.2 Order cost and wholesale price for order time

nonlinear equations. So, we adopt the numerical analysis to explain our conclusions. Firstly, the parameters are as follows: $D = 1000$, $p = 80$, $k = 5$, $T = 40$, $t_0 = 5$, $c = 15$, $\sigma = 600$. Then using the solution above, we can obtain the optimal order price for original decisions model is $\overline{w} = 45$ and the order quantity is $\overline{Q} = 742$, which are all as the benchmark to consider the performance of the QR system.

Then, the profits function for the retailer, the nonlinear lead time-based wholesale price and order cost and the profit function for the manufacture and supply chain are as follows in Figs. 139.1, 139.2, 139.3 and 139.4.

As seen in the Fig. 139.2, shorten lead time increases the wholesale price and order cost. Although shorten lead time can enhance the forecast accuracy and reduce the stock losses in QR system, the compressed order time also increase order cost in the production period. So, the manufacturer will charge the high order wholesale price with the order time. Then, the retailer must tradeoff between the order cost and the market forecast accuracy. Form Fig. 139.1, the decision function are concave function with the order time, i.e., there exists an optimal value for retailer with the profit function with the order time (= 21) and the optimal order time doesn't lie in the endpoint. Clearly from Figs. 139.3 and 139.4, the QR system is also beneficial to manufacture and supply chain within limit interval. Hence, it's advisable to entitle the retailer to determine the order time in QR system due to his advantage on information.

Fig. 139.3 Profit of manufacturer for order time

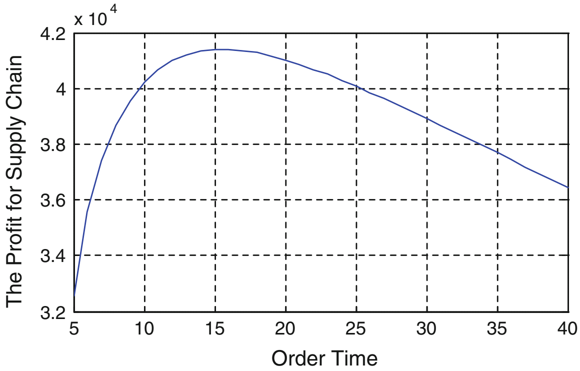


Fig. 139.4 Profit of supply chain for order time

139.3.2 The Effects of the Market Risk

Furthermore, we check the effects of the forecast error on the time-based decisions. So, we set the market risks equate to 800, 700, 600, 500 and 400, respectively. According to different market risk, the profit functions for retailer in Fig. 139.5, and the optimal order times for the retailer are presented in Fig. 139.6. From the Figs. 139.5 and 139.6, we can see that the market risk decrease the retailer's profit and also delay the order time. To keep the completeness, we also consider the effects on profit for manufacturer and supply chain as in Figs. 139.6 and 139.7. From Figs. 139.6 and 139.7, the market risk reduces the manufacturer's profit as well as the supply chain. So, shortening the lead time to reduce the market risk by updating information is an effective method to improve the supply chain performance. Especially, the effect of QR system is obvious and significant when the market risk is high (Fig. 139.8).

Fig. 139.5 Profit of retailer with different σ

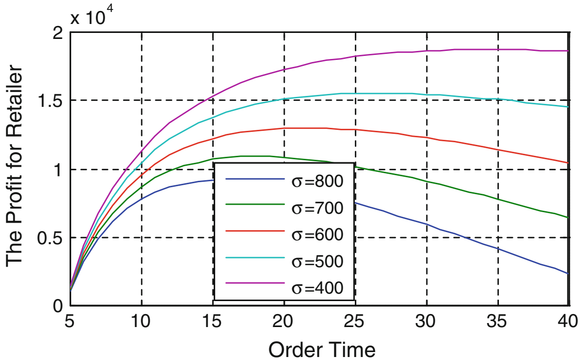


Fig. 139.6 Optimal order time for different σ

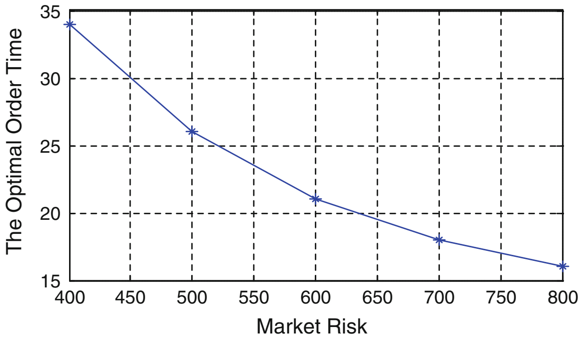
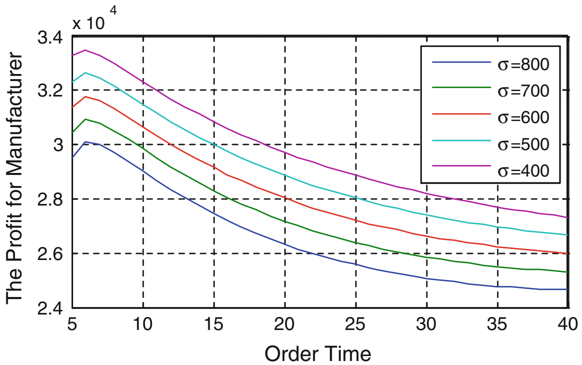


Fig. 139.7 Profit of manufacturer with different σ



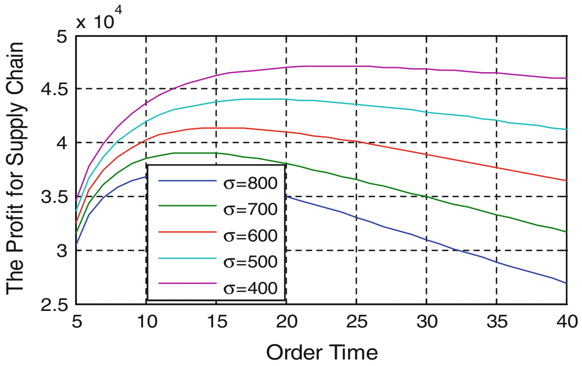


Fig. 139.8 Profit of supply chain with different σ

139.4 Conclusion

By using the time-variant variance of market demand, we consider the time-based order decisions-making problems in supply chain for the retailer and the manufacturer. By embedding the nonlinear lead time cost, we can overcome the extreme conclusion on time-based decisions-making and obtain the optimal order time for the retailer, also indirectly prove the effect of QR system in the supply chain. The result shows that to shorten lead time with QR system can benefit to each member in supply chain, especially when the market risk is very high. Also, the problem analyzed in this paper can be further explored in a number of directions. For example, the current model can be extended to include multiple retailers.

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Chapter 140
The Vertical Division of Agricultural Industrial Chain and Its Selection of Institutional Arrangements: From the View of Transaction Cost Economics

Yafei Wang and Jin Ren

Abstract The specialization of agriculture has promoted the formation and development of agricultural industry chain. It not only has increased the revenue, but also increased the trading frequency and transaction cost in agricultural industry chain. Because of the dilemma of vertical division in agricultural industry chain, the study and practice of effective institutional arrangements and structure can make effective connection and integration of farmers and leading business in agricultural industry chain, which is significant in increasing the stability and efficiency of vertical division in agriculture. The paper makes systematic analysis on the type, properties, selection and dynamic evolution of institution from the view of agricultural division and institutional economics.

Keywords Agricultural division · Agricultural industrial chain · Institutional arrangements

Developing and extending agricultural industrial chain, increasing agriculture specialization, and the development of modem agriculture, which are all important ways to change the urban and rural areas of China's "dual structure", increase farmers' income, bring out harmonious development both in urban and rural, and build up the new socialist countryside. As a modern form of industrial organization in division economy, industrial chain means a kind of chain structure which connects relevant economic activity, economic process, the production phase, required by the inside technical and economic association. Considering about the agricultural industry vertical relationship, it mainly refers to the division and cooperation relations between firms and farmers, which have been build up in the process of specialization. The study and practice of effective institutional

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arrangements and structure have significant meaning in the connections of farmers and leading firms, the stability of agricultural chain and the efficiency of vertical division of labors.

There are some relevant researches focus on the content of agricultural chain and organizational models, but few of them have combined the governance of agricultural division and vertical relations in agricultural industrial chain. The paper carries out a systematical analysis of vertical division of agricultural industry chain from the view of division of agricultural and institutional economics, including the institution type, properties, institution selection and dynamic evolution.

140.1 The Internal Logic of the Evolution of Agricultural Division and Agricultural Industrial Chain

Adam Smith believed that the division of labor and professional development is a source of economic growth. And the division can improve productivity, which is the key point in increasing national wealth (Smith 1994). Marshall's contribution to the division of economic is mainly reflected in the increasing returns and research of industrial organization. He focused on represented companies, and analyzed the relationships in division, industrial organizations and increasing returns from industrial layout, scale of production and business enterprises management functions both in external and internal economics. Young released the classic paper "Increasing returns and economic progress", which is thought to represent the best in the research of division and specialization. Young used three concepts to describe the division of labor, including each person's professional level, the length of indirect production chain and the number of product categories in the chain. Young's key idea is the relationship between division of labor, increasing returns and the evolution of industrial structure. He is the first one to demonstrate the market size and roundabout production, the interaction of inter-industry division and self-evolution mechanism (Young 1996). Schultz thought that the economic growth comes from specialization, division of labor and increasing returns to scale, with particular emphasis on specialized human capital. Becker and Murphy proposed the accumulated knowledge "spillover effect" in their book "division of labor, coordination costs and knowledge", which has been set up by arrow. They didn't agree with Smith that the division of labor does not restrict by market range, but mainly by the "coordination cost" (the equivalent of transaction costs and organizational costs) limit. Xiaokai Yang thought that the division of labor has promoted the economic division of labor, which also brings costs of coordination in the meantime. Thus, a scientific and effective coordination mechanism is significant important. From the agricultural development practice both home and abroad in recent years, we can see that division and specialization have economies of scale, technological and institutional innovation, knowledge spillovers, which also prove that the agriculture division and specialization are important explanatory variables of the economic evolution of industrial organization and the economic growth.

However, the profit of division is not the only explanatory variable of the agricultural industrial chain extension and its efficiency. The developments of agricultural division and specialization have promoted the efficiency of agricultural production and agricultural market expansion, resulting in a roundabout mode of production and extension of production chain. Besides, the division within the enterprise also shifts to the outside market. As long as the division and specialization can reduce the operating costs, marginal costs, or average costs, the agricultural industry will continue to generate a chain organization. However, the specialized division itself has two sides, one is saving cost, and the other is increasing the transaction costs. In the process of division and specialization, agricultural production becomes more circuitous, trade chain has been extended, and transaction costs also increases with the number of transactions. Therefore, the division economy may be offset by the transaction cost.

Case in the "corporate nature" for the first time put forward the concept of transaction costs with a general sense, which has created a precedent for economic analysis. He defined the transaction costs as information search costs, negotiation and contracting costs, monitoring and enforcing cost. Williamson set up an analytical framework as "transaction—an agreement—economic organization structure". And he thought that contract drafting; negotiation and maintenance costs were pre-transaction cost. On the contrary, the dispute due to improper adjustment, the correction cost, the operation management agency costs, and the cost for contracting parties to achieve mutual benefits, they are all after transaction cost. Besides, Williamson also believed that the transaction costs came from the bounded rationality, opportunism and asset specificity (William and Karen 1985). Barzel divided transaction cost into endogenous and exogenous transaction costs (William and Karen 1985; Michael 1999).

Thus, in the formation and development progress of agricultural industry chain, because of the dilemma of division of labor, we need to focus on the transaction cost, and select effective way to save transaction cost, improve transaction efficiency, and expand the size of market institutional division arrangements. Institutional division arrangements and organizational innovation have played important role in the evolution progress of agricultural industry.

140.2 The Type and System Properties of Agricultural Industrial Chain Institutional Division Arrangements

According to the relationship between leading enterprises and farmers, there are three types of transaction relationship, modes and institutional arrangements for them: market specialization, hybrid organization, and vertical integration.

Market specialization. Leading enterprises and farmers coordinate market transactions according to price mechanism, supply and demand relationship and competition, which is pure market transaction.

Vertical integration. Vertical integration refers to corporations in the upstream (downstream) of agricultural industry chain make purchase of part or all shares of business in downstream (upstream), also known as vertical acquisitions. Here we mainly refers to leading enterprises rely on administrative bureaucratic system to replace the market transaction relationship with farmers, and organize agricultural production. For the vertical integration of agricultural chain, some are led by leading enterprises, farmers invest or using land as shares. Furthermore, some leading enterprises set up agricultural production base, recruit and train farmers as employees, and do some production and business activities.

Hybrid organization. This kind of institutional arrangement is between the pure market transactions and vertical integration, which has both properties of market and business. It has made up planning and market allocation together. In this kind of arrangement, leading enterprises make contract with farmers, and keep a repeated, long-term, stable agricultural trading relationship (Luo 2000; Luo and Li 2002).

140.3 The Analysis on Institutional Division Arrangements of Agricultural Industry

According to the basic view of new institutional economics, the vertical division of industry chain has the same nature with the choice of economic organization. Transaction cost theory tells us that economic organization is not innate, but the choice of market with "profit maximization". And based on the contrast of "cost-benefit", the transaction costs are the most important variables. With regard to the evolution of division and transaction efficiency, and views like transaction costs and specialization are crucial in the selection of economic organization, Xiaokai Yang and Yongsheng Zhang have a detailed and vivid explanation in their book "new classical economics and the infra-marginal analysis". Furthermore, Williamson linked transaction and economic organizations together, and believed that transaction characteristics determined the form of economic organization, and the specific institutional arrangements (Yu and Guan 2006).

For the agricultural chain organizations, according to the division and transaction cost economics, if the specialization is within the agricultural enterprises, which means agricultural enterprises put farmers' production inside the enterprises, there will be two effects, one is the saving of market transaction costs, the other is the increase of management cost of internal organizations. On the contrary, if we separate the farmers and agricultural enterprises, transaction cost will increase and management cost will fall down. Therefore, the comparison of transaction cost and management cost is the basis for the division of institutional arrangements of both farmers and enterprises. The following is the general decision progress of division institutional arrangements for both farmers and enterprises. In order to better analysis the optimize decision-making process, we have following assumptions: (1) we use B_f and B_m as the benefits of internal division and market division, use C_f and C_m as the transaction cost of internal division and market division, and make Q as the output. (2) Transaction costs or expenses are separated with external economic environment. (3) We do not consider about the structure of agricultural markets. (4) We assume that there are only two economic entities on the agricultural chain, which are agricultural enterprises and farmers. Now we think about the logic as follows, and there are two cases.

The first scenario: if the income of internal division is equal to the market division, and benefits are bigger than costs (to ensure the possibility of economy of division), which means $B_f = B_m$, $B_f > C_f$, $B_m > C_m$. Thus we can say that if we put division inside, the total cost is the sum of internal price of enterprise (IC) and management cost (IZ), which is $C_f = IC + IZ$. Meanwhile, if we put division in the outside market, the total cost is the sum of outside price (OP) and transaction cost between enterprises and farmers (TC), which means $C_m = OP + TC$. Here the internal price means the transaction price coordinated by agricultural enterprises with their authority. And the outside price means "outsourcing" price, which is coordinated by the supply and demand mechanism of the market. In order to simplify the analysis, now we assume that both inside and outside division have the same efficiency, which also means internal price is equal to the outside price (OP = IC). Therefore, agricultural enterprises prefer vertical integration or market division, depends entirely on the comprehensive comparison between TC and IZ. When the market transaction cost is greater than the internal management cost, agricultural enterprises will prefer vertical integration, and internalize scattered farmers together. While the management cost is greater than the market transaction cost, enterprises will choose market division, and use price and supply–demand mechanism to reduce the high organization and management costs.

The second scenario: we make benefits and costs dynamic, and assume that marginal cost is increasing, while marginal return is decreasing:

$$\frac{dC_f}{dQ} > 0,\ \frac{d^2C_f}{dQ^2} > 0,\ \frac{dB_f}{dQ} > 0,\ \frac{d^2B_f}{dQ^2} < 0,$$

$$\frac{dC_m}{dQ} > 0,\ \frac{d^2C_m}{dQ^2} > 0,\ \frac{dB_m}{dQ} > 0,\ \frac{d^2B_m}{dQ^2} < 0.$$

Now the vertical axis indicates the transaction cost and benefits of division institutional arrangements, and the horizontal axis represents the output of the division institutional arrangements. Now we put the corresponding transaction cost curve and yield curve into the coordinates, we can clearly find that different industrial chain institutional arrangements have different cost-benefit structures, and they have their own application way (Dekker 2003).

Fig. 140.1 The division inside enterprises because of vertical integration

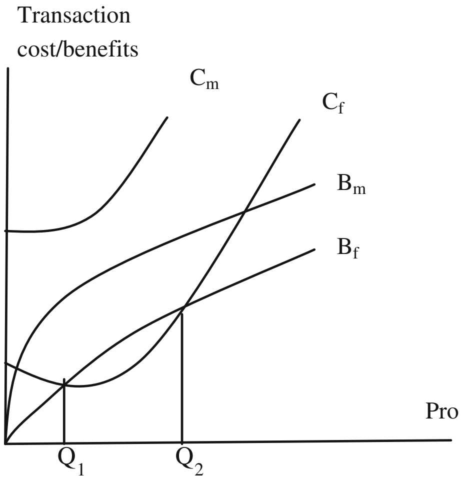
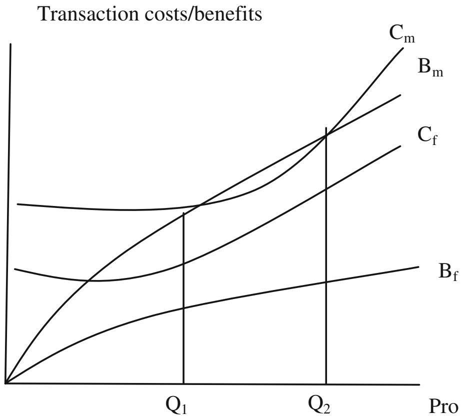


Fig. 140.2 Market division



It can be seen from Fig. 140.1, when the output of division Q, $Q_2 > Q > Q_1$, $B_f > C_f$, and $C_m > B_m$, the most optimal decision of leading enterprises and farmers are to choose the internal division. Leading enterprises can put farmer's production into the enterprises, and coordinate agricultural production through their authority.

It can be seen from Fig. 140.2, when the output of division Q, $Q_2 > Q > Q_1$, $C_f > B_f$, and $C_m < B_m$, the most optimal decision is to choose market division, which means the market trading relationships are more favorable for both leading enterprises and farmers.

We can see from Fig. 140.3, when the output of division Q, $Q_2 > Q > Q_1$, and $C_m > C_f$, this means the internal division of enterprises can reduce transaction costs. Besides, $B_m > B_f$ means market division has advantages of getting more benefits. Thus, we can see that no matter taking market division or internal division,

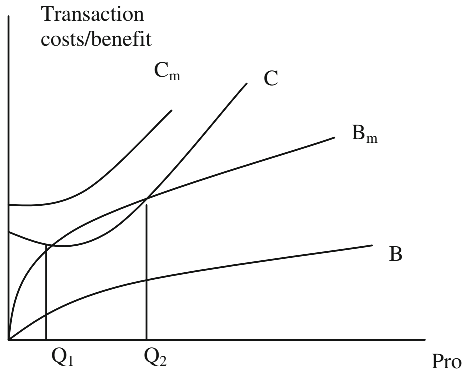


Fig. 140.3 Hybrid organizations

we can't get all the benefits of division economy. Leading enterprises and farmers can make contract deals, and take the hybrid organizations, which can help them to get the respective advantages of both sides (Yu and Guan 2006; Dekker 2003).

Thus, for the specialization of agricultural enterprises and farmers, what is their best choice, depends on the comparison of transaction costs and benefits, and there is no division institutional arrangements which are suitable in any situation.

140.4 The Dynamicevolution of Division Institutional Arrangements of Agricutural Industrial Chain

The division institutional arrangements of industrial chain depend on the transaction cost and benefits, which is not static. On the contrary, as various factors have impact on the transaction costs and benefits, industrial chain division is in the progress of integration (Gereffi and Korzeniewicz 1994; Yang and Shi 1992). Based on the above analysis, we assume that transaction cost and benefits are established stale. In fact, with the technological innovation and development of external economic environment, the transaction cost and benefits of each division institutional arrangements are changing all the time. Therefore, consider about the maximum benefits, agricultural enterprises and farmers will make some adaptive adjustment to the division arrangement, which means that the three kinds of division institutional arrangements are in dynamic evolution and transformation process (Sykuta and Cook 2001; Williamson 1985a).

Williamson made economic activity organization dichotomy forward to trichotomy as "business—intermediate—market". He believed that with the bounded rationality and opportunism, the asset specificity, transaction frequency and uncertainty were key factors in determining the transaction costs, which codetermine the choice of economic organization on the division institutional arrangements. When the economic organizations have selected the appropriate regulatory structures or institutional arrangements, the transaction cost will low down;

otherwise they need to pay for higher transaction fee, or even lead to fail transaction. The higher specificity of assets, greater the uncertainty of the transaction and higher frequency of transaction, the more opportunistic behavior and threats will be. With the high transaction cost caused by the specialization, the agricultural enterprises will prefer vertical integration, and make farmers' production inside. The three key factors are closely related to the different characteristics of industry and product features. Therefore, market division, intermediate division of labor and vertical integration are symbiotic (Williamson 1985b). Market division has the highest degree of market transaction, vertical integration has the highest degree of internal transaction, and the hybrid is between the two above.

In addition, the geographic concentration, market-oriented degree, innovation of trading technology and management system of agricultural trade, all may affect the transaction cost, and then lead to the transformation of division institutional arrangements. For example, the geographical concentration of transactions can greatly save exogenous transaction costs, and decrease endogenous transaction costs through saving information costs, which can help to improve transaction efficiency, and promote division of labor. The development of market economy reform and market mechanisms can constrain opportunistic behavior, and effectively reduce transaction costs, especially endogenous transaction costs, thereby enhancing the efficiency of transaction. Agricultural business management system innovation can greatly reduce the endogenous transaction costs caused by uncertainty, and provide incentives for technological innovation, which can improve transaction efficiency. Agricultural trading technology innovation can reduce exclusive cost, and greatly save assessing and monitoring cost, thereby improving transaction efficiency and promoting agricultural division and specialization (Bolton and Whinston 1993; Wenli et al. 2000).

140.5 Conclusion

The development of division and specialization is an important source of world economic growth. However, specialization itself has two sides. With the enhancement of roundabout production, the extension of industrial chain, and the increase of transaction links, the transaction cost is increasing all the time with the number of transactions. Therefore, for various kinds of effective organization and coordination of division institutional arrangements, the comparison of transaction costs and benefits, is significant important to the right choice of suitable institutional arrangements. Because of transportation, market-oriented degree, transaction technology, management tools and other external economic technology environment are dynamic, which caused the continuous change of transaction costs and benefits of the agricultural chain. Thus, the agricultural division institutional arrangements are dynamically adjusted. Therefore, with the development of division of labor and specialization, the right selection of division institutional arrangements and regulatory structure, which is adapt to the characteristics of agricultural industry or product, is significant for the effective organization and coordination of the division of agricultural industry chain, the extension of agricultural industry chain, the development of modern agriculture, the improvement of the competitiveness of agricultural industry, the expansion of agricultural market size, the increase of added value of agriculture, and the improvement of farmer' wealth.

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Chapter 141
An Analysis for Multi Plant Location Problem Under Concurrent Implementation of Different Carbon Policies

Zhen Chen, Qiu-hong Zhao and Hai-tao Zheng

Abstract This paper analyzes the influence of concurrent implementation of three different carbon policies: carbon tax, carbon trade, carbon offset to the company's multi plant location decisions, while multi capacity of any plant is considered. We present a mixed integer math model with the objective to minimize the total cost within the given period. The numerical results and sensitive analysis show that the location decision depends on several factors including the level of carbon tax and the price of carbon trade and carbon offset.

Keywords Carbon policies · Plant location · Multi capacity

141.1 Introduction

The Intergovernmental Panel on Climate Change (IPCC) reports that global warming poses a grave threat to the world's ecological system and the human race, and it is very likely caused by increasing concentrations of carbon emissions, which mainly results from such human activities as fossil fuel burning and deforestation. In order to alleviate global warming, the United Nations (UN), the European Union (EU), and many countries have enacted legislation or designed mechanisms to curb the total amount of carbon emissions. There are three main carbon policies: carbon tax, carbon trade, carbon offset. Carbon tax is a policy that the government makes an emission constraint for a company and levies tax on the

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company's exceeding carbon emission. Carbon trade is a policy that companies can trade the amount of carbon emission in the carbon emission exchange. Companies can buy carbon offsets in order to comply with caps on the total amount of carbon dioxide they are allowed to emit (Rosič et al. 2009).

There are a few studies on the operations decisions under carbon emission regulations. Kim et al. (2009) examine the relationship between the freight transport costs and CO_2 emissions in given intermodal and truck-only freight networks by multi-objective optimization. Hoen et al. examine the effects of two regulation mechanisms (emission cost vs. emission constraint) on the transport mode selection decision and suggest that policy-makers impose a constraint on freight transportation emissions. Pan et al. (2010) examined the environmental impact of pooling of supply chains, and they found the supply network pooling is an efficient approach in reducing CO_2 emissions. Hua et al. (2011) investigates how firms manage carbon footprints in inventory management under the carbon emission trading mechanism. To the best of our knowledge, there are no papers about the effects of the concurrent implementation of three main carbon policies on companies' operations. However, in the reality, several carbon policies may be carried out by the government at the same time, like the carbon policies in Europe Union. And, since the environment problem is more and more severe now, this may be a trend of other governments' policy.

The multi plant location problem is similar to the capacitated warehouse location problem (CWLP). Mathematically, they can be formulated as a mixed integer program with a certain number of potential warehouses or plants and certain number of customers. The objective is to choose the most appropriate plants to minimize the total cost including the fixed cost associated with plants and the transportation cost. The difference is that you can choose the plant production capacity in the former problem while in the latter situation the warehouse's capacity is a constant value. To our review, there are few papers about the multi plant location problem. However, in the real situation, managers always have some choices of the production capacity with the common sense that the larger capacity plant can meet more demands of the customers but with a higher fixed cost while the smaller plant has cheaper fixed cost but meets less demand. On the other hand, under carbon policies, managers should pay more attention on the plant's capacity because it has great effects on the carbon footprint.

The multi plant location problem is the same with CWLP in the computation principles, so the algorithms of CWLP are adapted to solve it. Akinc and Khumawala (1977) propose a branch-and-bound solution method. Bartezzaghi et al. (1981) presented a tree search algorithm based upon a lower bound derived from a transportation problem and gave computational results for problems involving up to 12 potential warehouse locations and 40 customers. Guignard-Spielberg and Kim (1983) presented a lower bound for the problem based upon lagrangean relaxation. Computational results are reported for problems involving up to 20 potential warehouse locations and 35 customers. Barcelo and Casanovas (1984) presented an algorithm based upon the automatic generation of cutting planes in an attempt to move the solution of the linear programming relaxation of the problem closer to the optimal mixed-integer solution. Computational results are reported for problems involving up to 30 potential warehouse locations and 50 customers. Beasley (1988) incorporates the lower bound and the reduction tests into a tree search procedure. By this way, it is able to solve problems involving up to 500 potential warehouse locations and 1,000 customers.

The rest of this paper is organized as follows: In Sect. 141.2 we formulate the multi plant location model under the concurrent implementation of three carbon policies. In Sect. 141.3 we provide some numerical examples and make sensitive analyses to gain practical insights from the analytical results derived in Sect. 141.2. Finally we conclude the paper and suggest topics for future research in Sect. 141.4.

141.2 Model Formulation

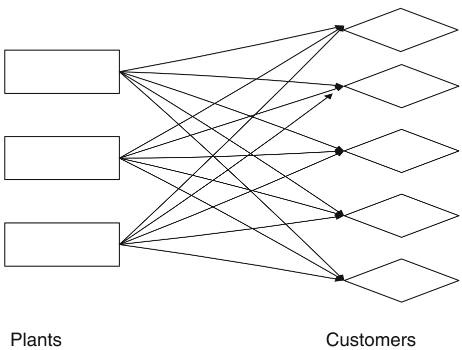
The multi plant location problem is in fact a transportation problem and the distribution network is like Fig. 141.1.

In our model, we assume that the company chooses some customer's locations to build up plants. The production capacity of the plant is assumed to have several levels and the decider maker chooses one production level for each plant. We also assume that the cost and carbon emissions in the transportation are only related to the distance and the volume of the goods transported.

The following notation will be used to describe the model:

$I = \{1, 2, \ldots, n\}$	the sets of plants
$J = \{1, 2, \ldots, m\}$	the sets of customers
$K = \{1, 2, \ldots, s\}$	the sets of capacity levels of plants
g_{ik}	the fixed cost of setting up plant i with a capacity level k per unit time
v_{ik}	the unit cost of operating in plant i
c_{ik}	the maximum capacity of plant i with a capacity level of j
d_j	the demand of customer j per unit time

Fig. 141.1 The structure of distribution network



l_{ij}	the distance of plant i to customer j
b	unit transportation cost
x_{ijk}	the volume of goods transported from plant i with a capacity level k to customer j
$\widehat{g}_{ik}$	the volume of carbon emission when setting up plant i with a capacity level k
$\widehat{b}$	unit carbon emission in transportation
α	carbon tax rate
L	the upper limit of the carbon emission per unit time
e_t	the volume of carbon traded
e_o	the volume of carbon offsetted
p_t	the price of carbon in trading
p_o	the price of carbon in offsetting
Z_{ik}	equals 1 when setting up plant i with a capacity level j, equals 0 when not
Z_t	equals 1 when the company trades carbon, equals 0 when not
Z_o	equals 1 when the company offsetts carbon, equals 0 when not

Model formulation:

$$\begin{aligned} \min & \left[\left(\sum_{i\in I}\sum_{k\in K} g_{ik} + \sum_{i\in I}\sum_{k\in K} v_{ik}c_{ik}\right)Z_{ik} + b\sum_{i\in I}\sum_{j\in J} l_{ij}x_{ij}\right]^{+} \\ & - p_t\left[L - \left(\sum_{i\in I}\sum_{k\in K} \widehat{g}_{ik} + \sum_{i\in I}\sum_{k\in K} \widehat{v}_{ik}c_{ik}\right)Z_{ik} - \widehat{b}\sum_{i\in I}\sum_{j\in J} l_{ij}x_{ij}\right]^{+} \\ & + \alpha\left\{\left[\left(\sum_{i\in I}\sum_{k\in K} \widehat{g}_{ik} + \sum_{i\in I}\sum_{k\in K} \widehat{v}_{ik}c_{ik}\right)Z_{ik} + \widehat{b}\sum_{i\in I}\sum_{j\in J} l_{ij}x_{ij} - L - q_tZ_t - q_oZ_o\right]^{+}\right\} \\ & + p_tq_tZ_t + p_oq_oZ_o \end{aligned} \tag{141.1}$$

$$s.t. \quad \sum_{j\in J} x_{ij} - \sum_{k\in K} c_{ik}Z_{ik} \le 0 \qquad i = 1,\ldots,n \tag{141.2}$$

$$\sum_{i\in I} x_{ij} - d_j = 0 \qquad j = 1,\ldots,m \tag{141.3}$$

$$\sum_{k\in K} Z_{ik} \le 1 \qquad i = 1,\ldots,n \tag{141.4}$$

$$x_{ijk} \ge 0, e_o \ge 0 \qquad i = 1,\ldots,n;\ j = 1,\ldots,m;\ k = 1,\ldots,s \tag{141.5}$$

$$Z_{ik} = 0,1;\ Z_t = 0,1;\ Z_o = 0,1 \qquad i = 1,\ldots,n;\ k = 1,\ldots,s \tag{141.6}$$

Formula 141.1 is the total cost of the company per unit time.

Formula 141.2 represents that the customer demand must be meted.

Formula 141.3 represents that the amounts of goods transported from a plant could not exceed its capacity.

Formula 141.4 represents each plant must only have only one certain capacity level.

In Formula 141.5, e_t does not have positive or negative constraint; if $e_t > 0$, it represents that the amount of carbon the company buys from the carbon trade exchange; if $e_t < 0$, it represents the amounts of carbon company sells in the carbon trade exchange.

Formula 141.6 is 0–1 variables.

From the objective function, we can see that in order to minimize total cost, the decision maker would choose one or more carbon policies to take effect. From $\alpha\left[\sum_{i\in I}\sum_{k\in K}\widehat{g}_{ik}Z_{ik}+\widehat{b}\left(\sum_{i\in I}\sum_{j\in J}\sum_{k\in K}x_{ijk}l_{ij}-L-e_oZ_o-e_tZ_t\right)\right]$, we know that the location decision is closely related with α, p_t, p_o.

141.3 Numerical Results

In order to analysis the effects of carbon policies on the plant location decision; we use the data in Christofides and Eilon (1969) as the customer's locations. We choose 15 numbers and draw Fig. 141.2. The distance between them are listed in Appendix 1. For simplicity and better analysis of the influence of carbon policies to location decisions, we assume all the customers' demands are the same 2,500 and in our model the unit time is 1 year. The decision maker chose several locations from them to build plant to meet the demands of all customers.

We assume that there are two levels of the capacity of the plant and the date is based on cement plants. The values of some imputed parameters are listed in Table 141.1. As some papers have used, our data is based on an assumption that larger production capacity plants have smaller unit operating cost and unit operating carbon emission.

b is 0.5 yuan/ton km, $\widehat{b}$ is 0.00006 yuan/ton km, the initial carbon tax rate α is 10 yuan/ton, initial carbon emission L is 50,000 ton, carbon trading price p_t is 60 yuan/ton, carbon offsetting price p_o is 80 yuan/ton.

Fig. 141.2 Distance of customers

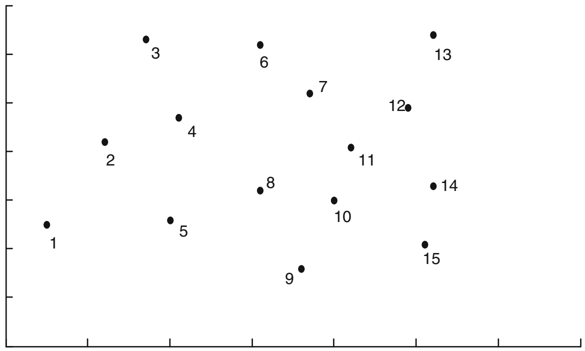


Table 141.1 Parameter values for two capacity plants

Capacity level (ton)	g_{ik} (yuan)	v_{ik} (yuan/ton)	$\widehat{g}_{ik}$ (ton)	$\widehat{v}_{ik}$ (ton CO_2/ton cement)
5,000	16,000,000	250	4,000	0.08
125,000	38,000,000	220	10,000	0.07

It is difficult to find the optimal solution, so we provide two feasible solutions. Solution 1 is that we build 5 high production capacity plants; Solution 2 is that we build 1 high capacity plant and 5 small capacity plants. For better understanding, we draw Figs. 141.3 and 141.4.

In the figures, the large triangle represents the high production capacity plant and the small one represents the low production capacity plant. For each plant, it not only meets the demands at its location, which the transportation cost can be ignored, also including the demands of other locations assigned for it. The details of the two solutions are listed in Tables 141.1 and 141.3.

From the above data, we can get the better solution is Solution 1 with carbon tax, that is that the decision maker choose to pay carbon tax and setting up three large production capacity plants.

We now analysis the better location strategy can be changed with the changing value of α, p_t, p_o.

Fig. 141.3 Solution 1

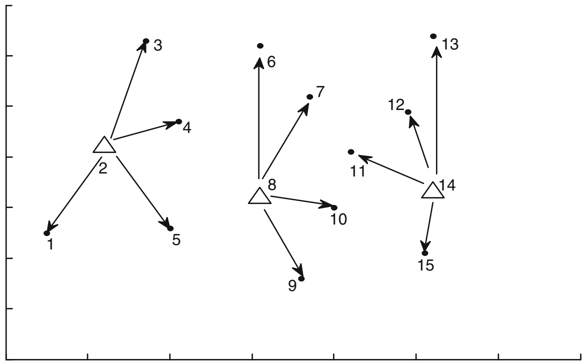


Fig. 141.4 Solution 2

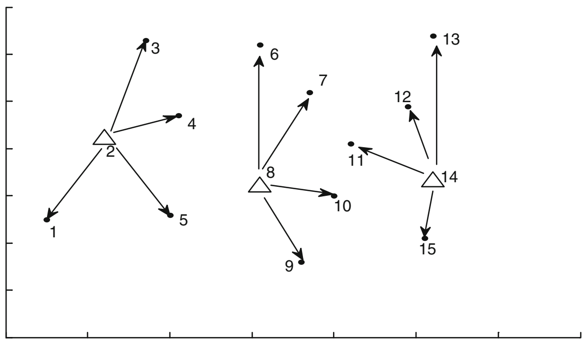


Table 141.2 Details of cost without carbon policy

Details	Solution 1	Solution 2
Fixed setting up cost	11400000	11800000
Operation cost	82500000	90000000
Transportation cost	22860053	15922577
Total cost without carbon related cost	116760053	117722577

Table 141.3 Carbon cost with L = 5,000, α = 10, p_t = 15, p_o = 20

Fixed carbon emission	30,000	30,000
Operation carbon emission	2,6250	28,750
Transportation carbon emission	27,432.063	19,107.092
Total carbon emission	83,682.063	77,857.092
Exceeding carbon emission	33,682.063	27,857.092
Total cost with carbon offsetting	117433694	123293995

141.3.1 $p_t > p_o$

In this situation, carbon offsetting is profitable. Because no matter what carbon constraint level is, companies can always offset carbon as more as possible, and then sell their carbon portion in the carbon trading market. We can view the carbon constraint and the carbon tax policy as meaningless. When $p_t$is large enough, that is $p_t \geq p_o + \frac{TC_2' - TC_1'}{C_{e1} - C_{e2}}$, where TC' is the total cost without carbon related cost and C_e is the exceeding carbon emission, Solution 2 is better, otherwise, if $\alpha < p_o - p_t + \frac{TC_2' - TC_1'}{C_{e1} - C_{e2}}$ Solution 1 should be the right strategy, conversely, Solution 2 is better because Solution 1 pays too much tax for its exceeding emissions.

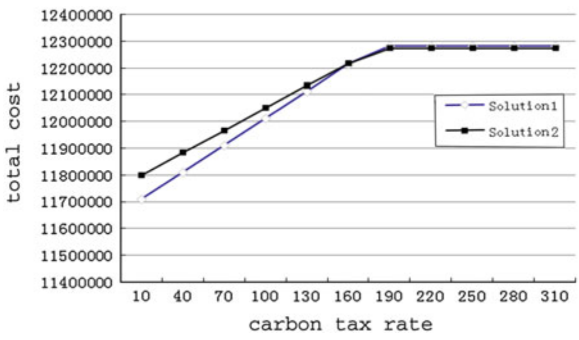
141.3.2 $\alpha < p_t < p_o$

In this situation, neither trading carbon nor carbon offsetting can decrease cost and paying carbon tax is always the best strategy. When $\alpha < p_o - p_t + \frac{TC_2' - TC_1'}{C_{e1} - C_{e2}}$, Solution 1 is better for whatever the carbon constraint level is, like Fig. 141.5 $(\alpha = 10, p_t = 15, p_o = 20)$. Otherwise, Solution 2 is better. Figure 141.5 $(p_t = 180, p_o = 200, L = 50,000)$ show the total cost change with the changing α.

141.3.3 $p_t < \alpha < p_o$ *or* $p_t < \alpha < p_o$

P_t is smallest now, so companies would trade all their exceeding emissions and Solution 1 is always better for whatever carbon tax rate is and whatever carbon constraint level is.

Fig. 141.5 Total cost with different carbon tax rate



141.4 Conclusions

This paper analysis the effects of concurrent implement of three carbon policies to the multi production capacity plants location decisions. We formulate a mixed integer model and present two feasible solutions. By adjusting carbon tax rate, carbon trading price and carbon offsetting price, we find that they can change the better solution. This can be a reference for managers to make location decisions.

In future research, it is necessary to employ an effective algorithm to get the optimal solution of this problem. Another extension of this problem may be conducted by considering more complex carbon policies, for example, the fluctuation the carbon trading price.

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Chapter 142
The Stock and the Purchase Strategy on the Nonlinear Diversification of Price to Time with Retailer Dominating

Shu-guang Han, Yi Xu and Jue-liang Hu

Abstract With the socio-economic changing, the retailer plays a more significant role in the supply chain. In this paper, a scenario is considered in which the retailer dominates a two-echelon supply chain which consists of one retailer and some manufacturers, and the price of raw materials is a nonlinear function to time. The retailer first determines the order quantity and the retail price, and then places some orders to the manufacturers. Then the manufacturers have to decide whether to accept the orders according to the enterprise profit and production capacity. We mainly develop the supply chain members' profit models and derive the retailer's optimal ordering quantity and retail price and the manufacturers' optimal orders which they accepted to maximize their profits.

Keywords Supply chain · Retailer dominate · Nonlinear function · Ordering strategy

142.1 Introduction

Supply chain management (SCM) is the management of a network of interconnected businesses involved in the ultimate provision of product and service packages required by customers (Harland 1996). Generally SCM can be divided into manufacturer-led mode (MS) and retailer-led mode (RS), according to the status of manufacturer and retailer in the supply chain (Shugan 1985). In the traditional industrial economy era, the manufacturer that controls the production of

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raw materials and technology can easily become the dominant of the supply chain. The study of supply chain ordering and pricing problem is mostly concentrated on the manufacturer-driven supply chain. References (Weng 1999; Tekin et al. 2001) considered manufacturer dominant the supply chain, and developed profit models to investigate the impact of price and remaining lifetimes for stock. Jian (2004) assumed the price be linear function to time, studied the laws of the prices, demands and profits.

With the socio-economic changing, the retailer plays more and more important role in the supply chain, the traditional mode that manufacturers as the leader is gradually transformed into a retailer-driven supply chain mode, large supermarket such as Wal-Mart and Carrefour are the typical dominant retailers. Some scholars have made research in this respect. Webster and Weng (2008) consider the manufacturer-controlled scenario and the distributor-controlled scenario. References (Kewen et al. 2009; Hua and L 2008) constructed a two-period model to discuss pricing and ordering problems for a dominant retailer. Chen and Xiao (2009) considered the supply chain consisting of one manufacturer, one dominant retailer and multiple fringe retailers. Li et al. (2010) developed the equilibrium of the retailer-led two class supply chain cooperate and non-cooperative models under market demand uncertainty. However, the change of manufacturer's production cost is seldom considered in the above references. Xianhao and Siyue (2009) considered the supplier's production cost and established the ordering decision model of retailer dominating the supply chain of short life-cycle products with some special production cost functions.

At present, some raw materials' prices have non-linear variation trend that first increasing and then decreasing, the manufacturer's production cost is also rapidly changing. In this paper, we assume the price of the raw material which the manufacturer needed is changing in non-linear cycle with the retailer dominating the supply chain. We establish the ordering and pricing models of the two-echelon supply chain which is composed of one retailer and some manufacturers.

142.2 Notations and Assumptions

Consider such a supply chain system for a product which consists of one retailer and some manufacturers, and the retailer dominates the whole supply chain. They make their decisions as follows: retailer determines the order quantity and the retail price judging from the market and other information, and then place the orders to the manufacturers. Considering the enterprise profit and the production capacity, the manufacturers decide whether to accept the orders or not, if the manufacturers accept the orders, then they determine the optimal order quantity to maximize their profits. Some notations for parameters and assumptions used in this paper are following.

142.2.1 Notations

retail price per unit product to consumers
wholesale price per unit product that the manufacturer charges from the retailer
retailer's ordering quantity
υ the price per unit raw materials that the manufacturer purchases
Q^* manufacturer's ordering quantity of the raw materials
k raw materials' amount of manufacturing unit product
m the time of manufacturing unit product
n the cost of manufacturing unit product except the purchase cost
T the time range of raw materials' price changing
h the unit cost of retailer's stock
Π_M the profit of the manufacturer
Π_M^* the optimal profit of the manufacturer
Q^* the optimal ordering quantity that the manufacturer accepts
Π_R the profit of the retailer.

142.2.2 Assumptions

(1) The retailer's revenue is composed of purchase cost and marginal profit, so the retailer can set retail price depending on the wholesale price and marginal price. We assume that: $p = (1 + \alpha)\omega$, where $0 < \alpha < 1$.
(2) Demand with price dependence is assumed to follow the additive demand type (Peruzzi and Dada 1999): $p = a - bQ$, where a and b are respectively a constant intersection and slop of the price curve function.
(3) Suppose the diurnal price of raw materials is related to the time and demand, the raw materials' price function to time is, where $T > 0$ and $c > 0$.

142.3 Model Building and Solving

142.3.1 Manufacturer's Optimal Decision

The retailer determines the products' order quantity and the retail price, and then place orders to the manufacturers at time t_1. The manufacturers decide whether to accept such orders according to the enterprise profit and delivery date or not. If the manufacturers accepted the orders, then they are required to delivery products at time t_2. The manufacturers begin to product after receiving the orders and deliver once after finished, therefore the manufacturers' stock cost is not considered here.

The manufacturer's total cost is the sum of the purchase cost and the production cost, thus the profit of the manufacturer is

$$\Pi_M = \omega Q - \upsilon Q^{'} - nQ.$$

Proposition 1 *When* $t_1 < T/2$ *and* $\frac{t_1+t_2-T}{m} \le Q \le \frac{t_2-t_1}{m}$ *hold, the maximum profit of the manufacturer is* $\Pi_M^* = (ck^2 - \frac{b}{1+\alpha})Q^{*2} + (\frac{a}{1+\alpha} + kt_1^2 - kTt_1 - n)Q^*$.

Proof When $t_1 < T/2$, $t_2 \ge t_1 + mQ$ and $T/2 - t_1 \ge t_2 - mQ - T/2$ hold, we can deduce $\frac{t_1+t_2-T}{m} \le Q \le \frac{t_2-t_1}{m}$. The purchase cost of raw materials is the lowest, if purchasing raw materials $Q^{'}$ at the time t_1, and they can deliver in time. Thus

$$\begin{aligned}\Pi_M &= \omega Q - \upsilon Q^{'} - nQ \\ &= \frac{1}{1+\alpha}(a - bQ)Q - (-t_1^2 + Tt_1 - ckQ)kQ - nQ \\ &= (ck^2 - \frac{b}{1+\alpha})Q^2 + (\frac{a}{1+\alpha} + kt_1^2 - kTt_1 - n)Q\end{aligned}$$

The maximum profit of the manufacturer is

$$\Pi_M^* = (ck^2 - \frac{b}{1+\alpha})Q^{*2} + (\frac{a}{1+\alpha} + kt_1^2 - kTt_1 - n)Q^*.$$

So $\frac{d\Pi_M}{dQ} = 2(ck^2 - \frac{b}{1+\alpha})Q + \frac{a}{1+\alpha} + kt_1^2 - kTt_1 - n$, and let $\frac{d\Pi_M}{dQ} = 0$, we get $Q_0 = \frac{a+(1+\alpha)(kt_1^2-kTt_1-n)}{2b-2ck^2(1+\alpha)}$.

Discussing the value of Q^*according to the signs of the second order derivative of Π_M, that are $ck^2 - \frac{b}{1+\alpha} = 0$,$ck^2 - \frac{b}{1+\alpha} > 0$ and $ck^2 - \frac{b}{1+\alpha} < 0$.

Lemma 1 *If* $ck^2 - \frac{b}{1+\alpha} = 0$ *holds, then* $Q^* = Q$.

Proof When $ck^2 - \frac{b}{1+\alpha} = 0$ and $\Pi_M = (\frac{a}{1+\alpha} + kt_1^2 - kTt_1 - n)Q$, in order to make the model significant, let $\frac{a}{1+\alpha} + kt_1^2 - kTt_1 - n > 0$, the function of profit is monotone increasing over the order quantity Q. Thus $Q^* = Q$ and $\Pi_M^* = \Pi_M(Q^*)$.

Lemma 2 *If* $ck^2 - \frac{b}{1+\alpha} > 0$ *holds, then* $Q^* = Q$.

Proof When $ck^2 - \frac{b}{1+\alpha} > 0$, we can get $\frac{d^2\Pi_M}{dQ^2} = 2(ck^2 - \frac{b}{1+\alpha}) > 0$. Because of $\frac{a}{1+\alpha} + kt_1^2 - kTt_1 - n > 0$, the function of profit is monotone increasing over the order quantity Q when $Q \ge 0$. Thus we can get $Q^* = Q$ and $\Pi_M^* = \Pi_M(Q^*)$.

Lemma 3 *When* $ck^2 - \frac{b}{1+\alpha} < 0$, *if* $\frac{t_1+t_2-T}{m} \le Q_0 \le \frac{t_2-t_1}{m}$ *and* $Q \ge Q_0$ *hold, then* $Q^* = Q_0$; *if* $\frac{t_1+t_2-T}{m} \le Q_0 \le \frac{t_2-t_1}{m}$ *and* $Q < Q_0$ *hold, then* $Q^* = Q$; *if* $Q_0 > \frac{t_2-t_1}{m}$, *then* $Q^* = Q$; *if* $Q_0 < \frac{t_1+t_2-T}{m}$, *then* $Q^* = \frac{t_1+t_2-T}{m}$.

Proof When$ck^2 - \frac{b}{1+\alpha} < 0$, we can get $\frac{d^2\Pi_M}{dQ^2} = 2(ck^2 - \frac{b}{1+\alpha}) < 0$, Π_M have the maximum value at the point Q_0, then we can deduce the lemma 3.

Proposition 2 *When* $t_1 < T/2$ *and* $0 \le Q \le \frac{t_1+t_2-T}{m}$ *hold, the maximum profit of the manufacturer is*

$$\Pi_M^* = km^2Q^{*3} + (kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})Q^{*2} + (\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n)Q^*$$

Proof When $t_1 < T/2$, $t_2 \geq T/2 + mQ$ and $T/2 - t_1 \leq t_2 - mQ - T/2$ hold, then $0 \leq Q \leq \frac{t_1+t_2-T}{m}$. The raw materials' purchase cost is the lowest, when purchasing raw materials Q' at time $t_2 - mQ$, and they can deliver in time. Thus the manufacturer's profit is

$$\begin{aligned}\Pi_M &= \omega Q - \upsilon Q' - nQ \\ &= \frac{1}{1+\alpha}(a - bQ)Q - [-(t_2 - mQ)^2 + T(t_2 - mQ) - ckQ)]kQ - nQ \\ &= km^2Q^3 + (kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})Q^2 + (\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n)Q\end{aligned}$$

The maximum profit of the manufacturer is

$$\Pi_M^* = km^2Q^{*3} + (kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})Q^{*2} + (\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n)Q^*.$$

$$\frac{d\Pi_M}{dQ} = 3km^2Q^2 + 2(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})Q + \frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n.$$

Next we discuss the value of Q^* for two cases:

$$(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})^2 - 3km^2(\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n) \leq 0$$

and

$$(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})^2 - 3km^2(\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n) > 0.$$

Lemma 4 *If*

$$(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})^2 - 3km^2(\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n) \leq 0$$

holds, then $Q^* = Q$.

Proof When

$(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})^2 - 3km^2(\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n) \leq 0$ holds, we can obtain that $\frac{d\Pi_M}{dQ} \geq 0$ for any Q because of $3km^2 > 0$. So the function of profit is monotone increasing over the order quantity Q if $0 \le Q \le \frac{t_1+t_2-T}{m}$. Thus we get $Q^* = Q$ and $\Pi_M^* = \Pi_M(Q^*)$.

When

$(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})^2 - 3km^2(\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n) > 0$, let $\frac{\mathrm{d}\Pi_M}{\mathrm{d}Q} = 0$, we can get

$$Q_1 = -\frac{2(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})}{6km^2} - \frac{\sqrt{4(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})^2 - 12km^2(\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n)}}{6km^2}$$

$$Q_2 = -\frac{2(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})}{6km^2} + \frac{\sqrt{4(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})^2 - 12km^2(\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n)}}{6km^2}$$

Let $\Pi_M = 0$, we can get

$$Q_3 = 0$$

$$Q_4 = -\frac{kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha}}{2km^2} - \frac{\sqrt{(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})^2 - 4km^2(\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n)}}{2km^2}$$

$$Q_5 = -\frac{kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha}}{2km^2} + \frac{\sqrt{(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})^2 - 4km^2(\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n)}}{2km^2}$$

Lemma 5 *When*

$(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})^2 - 3km^2(\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n) > 0$ *and* $kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha} > 0$ *hold, and also* $\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n > 0$ *holds, we have* $Q^* = Q$.

Proof When $kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha} > 0$ and $\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n > 0$, we can get $Q_1 < 0, Q_2 < 0$. Thus when $Q \ge 0$, it has $\frac{\mathrm{d}\Pi_M}{\mathrm{d}Q} > 0$, the function of profit is monotone increasing over the order quantity Q, with $0 \le Q \le \frac{t_1+t_2-T}{m}$. In this case, we have $Q^* = Q$ and $\Pi_M^* = \Pi_M(Q^*)$.

Lemma 6 *When*

$(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})^2 - 3km^2(\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n) > 0$ *and* $kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha} < 0$, $\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n > 0$, *if* $\frac{t_1+t_2-T}{m} \le Q_1$, *then*

$Q^* = Q$; if $Q_1 \le \frac{t_1+t_2-T}{m} \le Q_6$and $Q_1 \le Q \le \frac{t_1+t_2-T}{m}$, then $Q^* = Q_1$; if $\frac{t_1+t_2-T}{m} > Q_6$ and $Q_6 \le Q \le \frac{t_1+t_2-T}{m}$, then $Q^* = Q$, where $\Pi_M(Q_6) = \Pi_M(Q_1)$.

Proof From $kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha} < 0$ and $\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n > 0$, we can get $0 < Q_1 < Q_4 < Q_2 < Q_5$. If $0 < Q < Q_1$ or $Q > Q_2$, the profit function is monotone increasing over the order quantity Q; if $Q_1 < Q < Q_2$, the function of profit is monotone decreasing over the order quantity Q. So we get the lemma 6.

Lemma 7 *When $(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})^2 - 3km^2(\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n) > 0$ and $\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n < 0$ hold, if $\frac{t_1+t_2-T}{m} \le Q_5$, then the manufacturer refuses the order; if $\frac{t_1+t_2-T}{m} > Q_5$ and $Q_5 \le Q \le \frac{t_1+t_2-T}{m}$, then we have $Q^* = Q$.*

Proof When $\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n < 0$, we get $Q_4 < Q_1 < 0 < Q_2 < Q_5$. Thus if $0 \le Q \le Q_2$, it has $\frac{d\Pi_M}{dQ} \le 0$, the function of profit is monotone increasing over the order quantity Q; if $Q > Q_2$, it has $\frac{d\Pi_M}{dQ} > 0$, the function of profit is monotone decreasing over the order quantity Q. When$0 \le Q \le Q_5$, we can get $\Pi_M \le 0$ because of $\Pi_M(0) = 0$ and $\Pi_M(Q_5) = 0$. So the manufacturer's profit less than zero.

Therefore if $\frac{t_1+t_2-T}{m} \le Q_5$ and $0 \le Q \le \frac{t_1+t_2-T}{m}$, it has $\Pi_M \le 0$, the manufacturer will refuse the order; if $\frac{t_1+t_2-T}{m} > Q_5$ and $Q_5 \le Q \le \frac{t_1+t_2-T}{m}$, it has $\Pi_M > 0$, the function of profit is monotone increasing over the order quantity Q. In this case, $Q^* = Q$ and $\Pi_M^* = \Pi_M(Q^*)$ hold, otherwise the manufacturer refuses the order.

Proposition 3 *When $t_1 > T/2$ and $0 \le Q \le \frac{t_2-t_1}{m}$, the maximum profit of the manufacturer is*

$$\Pi_M^* = km^2Q^{*3} + (kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})Q^{*2} + (\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n)Q^*$$

Proof When $t_1 > T/2$ and $t_1 + mQ \le t_2$, which means $0 \le Q \le \frac{t_2-t_1}{m}$. The purchase cost of raw materials is lowest, if purchasing raw materials Q' at time $t_2 - mQ$, and they can deliver in the delivery period. Thus

$$\begin{aligned}\Pi_M &= \omega Q - \upsilon Q' - nQ \\ &= \frac{1}{1+\alpha}(a - bQ)Q - [-(t_2 - mQ)^2 + T(t_2 - mQ) - ckQ)kQ - nQ \\ &= km^2Q^3 + (kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})Q^2 + (\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n)Q\end{aligned}$$

The maximum profit of the manufacturer is

$$\Pi_M^* = km^2Q^{*3} + (kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})Q^{*2} + (\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n)Q^*.$$

We get $\begin{aligned}\frac{d\Pi_M}{dQ} &= 3km^2Q^2 + 2(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})Q \\ &+ \frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n\end{aligned}$.

Lemma 8 *When* $(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})^2 - 3km^2(\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n) \leq 0$ *we have* $Q^* = Q$.

Lemma 9 *When* $(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})^2 - 3km^2(\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n) > 0$, $kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha} > 0$ and $\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n > 0$, if $0 \leq Q \leq \frac{t_2-t_1}{m}$, then we get $Q^* = Q$, and otherwise $Q^* = \frac{t_2-t_1}{m}$.

Lemma 10 *When* $(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})^2 - 3km^2(\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n) > 0$ *and* $kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha} < 0$, $\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n > 0$, *if* $\frac{t_2-t_1}{m} \leq Q_1$, *then* $Q^* = Q$; *if* $Q_1 \leq \frac{t_2-t_1}{m} \leq Q_6$ *and* $Q_1 \leq Q \leq \frac{t_2-t_1}{m}$, *then* $Q^* = Q_1$; *if* $\frac{t_2-t_1}{m} > Q_6$ *and* $Q_6 \leq Q \leq \frac{t_2-t_1}{m}$, *then* $Q^* = Q$, *where* $\Pi_M(Q_6) = \Pi_M(Q_1)$; *if* $Q > \frac{t_2-t_1}{m}$, *then* $Q^* = \frac{t_2-t_1}{m}$.

Lemma 11 *When* $(kmT + ck^2 - 2kmt_2 - \frac{b}{1+\alpha})^2 - 3km^2(\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n) > 0$ *and* $\frac{a}{1+\alpha} + kt_2^2 - kTt_2 - n < 0$, *if* $\frac{t_2-t_1}{m} \leq Q_5$, *the manufacturer will refuse the order; if* $\frac{t_2-t_1}{m} > Q_5$ *and* $Q_5 \leq Q \leq \frac{t_2-t_1}{m}$, *then* $Q^* = Q$; *if* $Q > \frac{t_2-t_1}{m}$, *then* $Q^* = \frac{t_2-t_1}{m}$.

142.3.2 Retailer's Optimal Decision

The retailer determines the order quantity and the retail price according to the market and some other information. Suppose the daily market demand is a constant, so we can get the product stock of retailer using EOQ model.

Proposition 4 *The maximum profit of the retailer is*

$$\Pi_R = -\frac{\alpha b}{1+\alpha}Q^2 + (\frac{\alpha a}{1+\alpha} - \frac{h}{2})Q$$

Proof The retailer's total cost is the sum of the purchase cost and the stock cost, thus the profit of the retailer is

$$\Pi_R = pQ - \omega Q - h\frac{Q}{2} = \alpha\omega Q - \frac{h}{2}Q = -\frac{\alpha b}{1+\alpha}Q^2 + (\frac{\alpha a}{1+\alpha} - \frac{h}{2})Q$$

Lemma 12 *The retailer's optimal ordering quantity* $Q = \frac{a}{2b} - \frac{h}{4\alpha b} - \frac{h}{4b}$, *optimal retail price* $p = \frac{2a\alpha + h\alpha + h}{4\alpha}$.

Proof It is easy to get $\frac{d\Pi_R}{dQ} = -\frac{2\alpha b}{1+\alpha}Q + \frac{\alpha a}{1+\alpha} - \frac{h}{2}$.

And let $\frac{d\Pi_R}{dQ} = 0$, we get $Q = \frac{a}{2b} - \frac{h}{4\alpha b} - \frac{h}{4b}$.

Because $\frac{d^2\Pi_R}{dQ^2} < 0$, Π_R have the maximum value at the point Q. At the moment the price is

$$p = a - bQ = \frac{2a\alpha + h\alpha + h}{4\alpha}.$$

142.4 Conclusion

In this paper, we study the ordering and pricing problem of a two-echelon supply chain which consists of one retailer and some manufacturers with the retailer dominating the whole supply chain. We assume that the products' retail price is sensitive to the demand and the raw materials' price is related to time, and develop supply chain members' profit models.

The differences of this paper from others are that the price of raw materials is a nonlinear function to time, and the order quantity and the wholesale price are determined by the retail in the supply chain system. However the models in this paper also have some limitations, such as the daily market demand is a constant. In the future research, we could extend the models that the product daily demand is changeable.

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Chapter 143
Research on Allocation of Port Cargo Handling Machinery Based on Production Efficiency of Handling System and Energy Consumption

Xue-shu Liu and Bin Yang

Abstract At present, there are less economic researches on port cargo handling machinery configuration than researches about optimal scheduling port cargo handling machinery. Studies that take economic factors into account to establish the quantity allocation model of port cargo machinery mostly pursue the lowest cost or maximum operating efficiency and fail to consider the energy consumption of port cargo handling machinery. This study establishes the allocation model based on production efficiency and energy consumption of port cargo machinery following port cargo handling machinery allocation principles after analyzing the economic factors of port cargo machinery configuration. And this study helps improve the efficiency of general cargo port and reduce its energy consumption.

Keywords Port cargo handling machinery · Quantity allocation model · Production efficiency · Energy consumption

143.1 Introduction

Handling machinery constitutes the main productive activities that generate income for port industries but also requires huge initial capital investment. Therefore, it is significant to allocate the quantity of port handling machinery. Currently, there are many researches relating to configuration of port cargo handling machinery. For example, Dong Ming Wang proposed a new evaluation index, developed an integer programming model and solved the model using the dynamic programming principle (Zheng and Ma 2009; Dong and Guyong 2003; Zhang et al. 2005; Zhang 2007)

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However, careful analysis has discovered that, most of the researches on port handling machinery configuration problems departed from the perspective of optimal scheduling. The handling machinery configuration studies are mostly based on lowest cost or operational efficiency as the objective function for the consideration of energy consumption from the point of view of reducing the logistics cost of the equipment. These studies did not effectively control energy consumption and take energy saving and emission reduction in the port as a port management objective (Li 2006; Xing 2010).

Based on the above, this paper analyzes the basic factors influencing port cargo handling machinery configuration in accordance with the principles of handling machinery configuration, economically analyzed the scheme of configuration of port cargo handling machinery established a configuration model for cargo handling machinery based on production efficiency and energy consumption which will not only effectively control the handling costs but also improve production efficiency of the cargo terminal, while reducing the energy consumption of the port handling machinery as well as achieving the objective of saving energy and reducing emission.

143.2 Methodology

143.2.1 Configuration Principle

Configuration of port cargo handling machinery directly affects the process and efficiency of the cargo terminal's handling, thereby affecting the productivity of the entire port. To ensure the efficient and economic operation of the port cargo handling system, the handling machinery configuration should be according to the following principles (Malchow 2001; Bo 2002; Song and Wang 2006):

(1) Applicability and advanced principle: The nominal operating capacity and quantity of machinery are determined by various factors including the type of cargo. The basic principle of cargo handling machinery configuration must therefore be suitable to meet the demand for cargo handling. In addition, mechanical devices - handling machinery- have a certain degree of operating capacity during their economic life. This must therefore be fully considered in relation to obsolesce due to future technological development and progress in port handling machinery in order to maintain a high technology in their economic life cycle.

(2) Economic and systematic principle: economy is an import index of measuring port handling system. The economic benefit of port handling systems is directly reflected by the cost of acquisition of handling machinery, fuel costs and maintenance costs. The objective of port handling machinery configuration is to minimize the cost of handling machinery during its life cycle while meeting the operating demand under reasonable technological advancement.

Therefore a rational economic analysis of port handling machinery is of great significance for the effective control of their cost and improvement in production efficiency of the entire port.

143.2.2 Factors of Economic Influence

There are many economic factors that influence the configuration of port cargo handling machinery categorized into four major aspects: mechanical factor, handling method factor, cargo factors and port factor (Shank and Govindaraian 1996; Daganzo 1989; Cooper and Kaplan 1999).

(1) Mechanical factors: The technical performance, handling volume etc. of the handling machinery itself is an important factor which influences the configuration of port cargo handling machinery.
(2) Handling method factor: a reasonable port handling method scheme not only can make full use of handling machinery, but also avoid excessive waste of handling machinery.
(3) Cargo factor: cargo is the object of port handling operation and therefore the one factor that affects the configuration of port handling machinery the most.
(4) Port factor: The port factor is an important factor that influences the configuration of port handling machinery as it is the port that provides the basic infrastructure which determines the range and conditions within which the machinery and equipment will operate.

143.2.3 The Model Establishment

According to the above, the article establishes a configuration model of port cargo handling machinery based on the production efficiency and energy consumption with a full consideration of the energy consumption of handling machinery. The notation and model are as follows (Li 2006; Xing 2010; Bo 2002; Scharge 2004; Robinson 2005).

Notation:

m planning horizon {1,…,m}
n planning horizon {1,…,n}
z set of integers
p_j output per machine hour of handling machinery type i
c_{gi} annual fixed costs of per handling machinery type i
c_{bi} annual variable costs per handling machinery type i
x_i allocation quantity of handling machinery type i
y_i annual operation hours of handling machinery type i
k_{wi} equipment efficiency ratio of handling machinery type i
k_{li} equipment utilization ratio of handling machinery type i

p_j output per machine hour of handling machinery type j
q_j allocation quantity of fixed machinery type j

Model:

$$\mathrm{MAX}\frac{\sum_{i=1}^{m} p_i x_i y_i}{\sum_{i=1}^{m} c_{gi} x_i + \sum_{i=1}^{m} c_{bi} x_i y_i} \tag{143.1}$$

$$\mathrm{MIN}\sum_{i=1}^{m} c_{bi x_i} y_i \tag{143.2}$$

s.t.

$$\sum_{i=1}^{m} y_i - x_i \times k_{wi} \times 24 \times 365 \le 0 \quad \text{for all} \quad i \in m \tag{143.3}$$

$$y_i - x_i \times k_{wi} \times 24 \times 365 \times k_{li} \ge 0 \,\text{for all}\, i \in m \tag{143.4}$$

$$y_i - x_i \times k_{wi} \times 24 \times 365 \times k_{li}^{'} \le 0 \,\text{for all}\, i \in m \tag{143.5}$$

$$\sum_{i=1}^{m} p_i x_i \ge \sum_{j=1}^{n} p_j q_j \,\text{for all}\, i \in m,\ \text{all}\, j \in m \tag{143.6}$$

$$x_i, y_i \ge 0,\ \text{for all}\ x_i \in z, i \in m \tag{143.7}$$

The model maximizes the production efficiency of the port cargo handling system and production efficiency of the port cargo handling system (the ratio between total output and total investment of the port cargo handling system) and minimizes the variable costs of total investment in port cargo handling system. Constraint (3) specifies the rang of operating hours of handling machinery of type i. Constraints (4) and (5) specify the range of the utilization ratio of handling machinery of type i, ensure that cargo handling tasks are completed on time and avoid high intensity of work and a waste of money because of a large number of idle handling machinery. Constraint (6) ensures that the loading and unloading speed of handling machinery of type i can fully cooperate with the relevant fixed machinery.

143.3 Results

143.3.1 Data Analysis

This paper uses the data of A Port to examine the validity of the model. This article takes forklift system as a separate handling system after examining the actual situation of A Port

There are 43 forklifts used for cargo handling in the port cargo handling system of A Port whose different types are as shown in Table 143.1.

Relevant data analysis combined with the model and the actual situation of port cargo handling system is as below (Kim and Kim 1999).

(1) Equipment efficiency ratio and utilization ratio
We can calculate the forklifts' efficiency ratio and utilization ratio as shown in Table 143.2 in A Port general cargo handling system by the formula of equipment efficiency ratio and utilization ratio.
(2) Output per machine hour
Output per machine hour represents the shipment of handling through forklifts per hour and also means the production efficiency of forklifts. The values are as shown in Table 143.3.
(3) Fixed costs
Fixed costs of handling machinery consist of four parts: depreciation, major repair cost, benefit and cost-sharing whose values are as below in Table 143.4.

Table 143.1 Quantity configuration of forklifts in a port

Type	Rated capacity	Age	Quantity
PD30	3t	5	4
PD50	5t	15	25
PD60	6t	6	3
PD70	7t	15	3
TCMFD30T3	3t	1	2
TCMFD50T9	5t	1	3
HYSTERH7.00XL	7t	15	3

Table 143.2 Ratio of perfectness and utilization of forklift

Type	Perfectness ratio (%)	Utilization ratio (%)
PD30	98.08	9.30
PD50	82.08	31.17
PD60	85.67	24.22
PD70	86.79	38.87
TCMFD30T3	97.65	39.60
TCMFD50T9	94.37	31.03
HYSTERH7.00XL	89.12	38.79

Table 143.3 Output per machine hour of forklift in a port

Type	Inducement per machine	Work hour per machine	Average output per machine hour
PD30	7588.35	723	10.5
PD50	38909.51	2730	14.25
PD60	32807.43	2111	15.54
PD70	65768.08	3387	19.42
TCMFD30T3	53202.94	3444	15.45
TCMFD50T9	43874.99	2675	16.40
HYSTERH7.00XL	7949.99	3477	21.55

Table 143.4 Annual average fixed costs per forklift

Type	Depreciation	Major repair fund	Benefit	Cost-sharing
CPCD30	6401.67	1000.00	1005.32	26765.18
CPDC5	5208.14	411.64	3339.29	32351.51
CPCD60	11446.00	856.00	5822.04	25867.79
CPCD7	4928.75	756.50	3540.34	35654.17
TCMFD30T3	22916.00	1200.00	3000.37	27654.17
TCMFD50T9	41225.00	491.00	2536.09	26606.64
HYSTERH7.00XL	17441.50	1347.50	2797.19	30675.33

Table 143.5 Variable costs per forklift

Type	Running costs of material	Maintenance costs	Fuel costs	Variable costs
PD30	2.44	4.46	8.47	15.37
PD50	2.98	7.64	7.97	18.59
PD60	3.43	8.35	9.92	21.70
PD70	3.72	8.82	13.98	26.52
TCMFD30T3	0.24	5.58	8.18	14.00
TCMFD50T9	3.16	6.38	7.58	17.12
HYSTERH7.00XL	4.7	8.57	9.44	22.71

(4) Variable costs

Variable costs per forklift are made up of fuel costs, maintenance costs and running costs of material. The results are as follows in Table 143.5.

143.3.2 Model Calculation

A result as shown in Fig 143.1 can be calculated with Lingo after taking the objective function, constraints and relevant values into the model established in Sect. 143.2.

```
Local optimal solution found.
Objective value:                              3578196.
Extended solver steps:                              0
Total solver iterations:                           23
```

Variable	Value	Reduced Cost
X(1)	1.000000	4770.307
X(2)	2.000000	15502.04
X(3)	1.000000	16163.84
X(4)	2.000000	30381.52
X(5)	41.00000	0.000000
X(6)	2.000000	6140.908
X(7)	2.000000	10814.12
Y(1)	814.6800	0.000000
Y(2)	2730.492	0.000000
Y(3)	2121.672	0.000000
Y(4)	3405.012	0.000000
Y(5)	5209.239	0.000000
Y(6)	2718.228	0.000000
Y(7)	3398.004	0.000000

Fig. 143.1 Result of the model with lingo

143.4 Discussion

We have drawn the following conclusions by comparing the original configuration plan of general cargo handling machinery configuration in A Port with the new model.

(1) In the original configuration of forklift handling systems at A Port, with an annual throughput of up to 1,761,500,000 tons and the total annual costs of up to RMB 4,109,730 year-on-year and annual variable costs of up to RMB 2,190,821.The production efficiency value of handling system is 0.429.
    In the new configuration of forklift handling systems, the annual throughput is up to 3,787,000,000 tons and the total annual costs is up to RMB 6,320,329 year-on-year with annual variable costs of up to RMB 3,578,196. The production efficiency value of handling system is 0.599.
(2) The production efficiency value of new configuration is higher than that of the old one which means that the new configuration is better than the original one.
(3) To complete the same cargo throughput in the same year, the new configuration achieved RMB 823,224 less than the original one in terms of cost.

Variable cost per forklift is made up of fuel cost, maintenance cost and running costs of material. Fuel costs account for the largest proportion and running costs of materials account for the smallest proportion. Both are relatively stable whilst maintenance costs suffered great random fluctuations, and less controllable.

Therefore, if we assume that annual total fuel costs account for 50 % of annual total variable cost, of the new configuration this results in RMB 411,612 less than that of the original one. And if we assume the price per litre of petrol is RMB 8, the new configuration could save 51,451.5 litres of fuel than the original one.

By calculation, the model of port general cargo handling machinery quantity configuration considering production efficiency and energy consumption not only help improve the production efficiency of handling systems but also reduce energy consumption and pollutant emission of handling machinery which fully shows the usability and necessity of this study.

143.5 Conclusion

The study can help improve the production efficiency of general cargo port and reduce energy consumption and pollutant emissions of port general cargo handling machinery. The model described in this paper applies not only to forklifts as an example of general cargo handling machinery configuration issue but also applies to issues of other port general cargo handling machinery allocation. This model can also be applied to configure rationally cargo handling machinery in future by forecasting cargo throughput and appropriately changing the values of the other conditions.

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Chapter 144
Research on a Circular Economy Index System Frame of Manufacturing Industrial Chain

Ji-liang Zheng and Chen Zheng

Abstract Manufacturing industrial chain includes the upper, middle and lower industries of manufacturing industry. The focus of energy saving and emission reduction practice in the three industries are different in the construction of circular economy. It is necessary to build a unified circular economy index system under the condition and trend of green supply chain management. A unified circular economy index system frame or model is proposed here based on the analysis and comparison about the features, achievements and trend of circular economy development among each link industry of manufacturing industrial chain therefore. The idea and way of transmitting the unified environmental management requirement along industrial chain through setting up the weight variable is put forward at the same time.

Keywords Circular economy index system · Industrial chain · Manufacturing industry

144.1 Introduction

Manufacturing industrial chain includes the upper, middle and lower industries of manufacturing industry. With perspective of production chain, the upper reach industry mainly includes the mining and production of raw materials such as iron steel, nonferrous metal, building material, coal, and other raw materials, which is

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called as the resource industry in general; the lower reach industry provides the final products for consumer such as household appliance, motor vehicle and etc.; the middle reach industry produces intermediate products (primary products and industrial remanufacturing products) for the lower reach industry to supply parts or middle material, such as motor, integrated circuit plate or one carbon chemical products. So far, a lot of researches have been carried out on the circular economy or green product index system of the upper and lower reaches of manufacturing industrial chain, while research on the middle as an independent industry is much fewer. The built index system for both ends of industrial chain is independent for each other owing to different features of industries, which are classified into the different industries actually.

However, we found out that many items in the circular economy index system or green product index system are similar. Therefore, it is necessary to conduct a unified and systematic research on them. Under the condition and trend of green supply chain management, to transmit the unified environmental management requirements along industrial chain from an end to the other should be considered as well. Based on the above view point, after analyzing and comparing the circular economy or green product index system of the upper and lower reaches of manufacturing industrial chain as well as considering the characteristics of middle reaches industry, a unified circular economic index system frame or model for the whole manufacturing industrial chain with perspective of circular economy have been built up primarily, which may reflect the transmission of environmental management at the same time.

144.2 Analysis on the Component Parts of the Circular Economy Index System (CEIS) for Each Parts of the Manufacturing Industrial Chain

144.2.1 References Summarization

There are a lot of researches on the circular economy index system of the upper reach industry. For example, Cui et al. (2008) divided the index system of iron industry into three parts: resource consumption, comprehensive utilization and waste discharge. Li (2007) divided the index system of chemical industry into such parts as reducing utilization of resources, comprehensive utilization, recycle and reuse of resource, industrial structure and development capability of circular economy. Gao et al. (2007) divided the index system of yellow phosphorus industry into parts as efficiency, material recycle, technological innovation & achievement transformation capability, resource exploitation & ecological restoration, regulation & policy. Jiang and Zhang (2007) divided the index system of coal industry into several categories: management, economy, ecological protection, and circular economy. There are some researches with perspective of resource industries. For example, Sha and Ou (2008) classified the index system of mining industry as economic and social benefit, exploitation and utilization of mineral resources, comprehensive and recycle utilization, and ecologic environment protection. Shi (2008) divided the index system of mining industry into such parts as social economy, energy consumption, pollution discharge and recycle utilization. Zheng and Chen (2008) divided the index system of energy-intensive industries into three categories of economic performance, environmental performance and social performance, their particular indexes were given also.

In the lower and middle reach industry, evaluation index system of green product, a firm's green degree or green manufacturing system rather than circular economy index system are used generally. For example, Liu et al. (2000) built up a green product evaluation index system, including product's basic, environment, resource and economy property. Zhang and Jia (2005) established a firm's green degree evaluation index system, including cleaner level of production technology, compatibility between product and environment, "three wastes" discharge and disposal level in production process, characteristics of firm's resources and energy utilization, and social influence. Cao et al. (2006) constructed a firm's green degree evaluation index system, including product green level, cleaner level of production technology, and wastes discharge and disposal level. Shen and Ruan (2006) researched an evaluation system of green manufacturing system, including development degree, sustaining degree and fair degree. Zhang et al. (2009) published a book "*Green Product Evaluation System for Manufacturing Industr*y", three parts "economic attribution, technical attribution and green attribution" are included in its comprehensive evaluation index system of green product.

144.2.2 Analysis on the Component Parts of CEIS for the Upper Reach Industry

Most of the upper reach industry is energy-intensive industry (metallurgical industry, chemical industry, building material industry and power industry), which has the feature of high energy and material consumption and high emission level. Therefore, index system designed for these industries in the circular economy. There are four component parts of CEIS for the upper reach industry of the manufacturing industrial chain generally. These are summarized as below.

(1) Index of lowering energy consumption. It includes coal and electricity consumption. Most of it comes from production process, which are divided into three parts: mining, mineral separation and smelting.

(2) Index of improving use factor of mineral resource. They include mining availability, recovering factor of main mineral resource and accompanying mineral, average grade of utilized mineral, comprehensive use factor of mineral resource and etc.

(3) Index of three wastes controlling and recycling. ① waste water discharge under standard and reuse; ② dust, sulphur dioxide and carbon monoxide emission under standard and retrieve; under standard and retrieve; ③ slag discharge under standard and reuse.

(4) Index of lowering water consumption. It include fresh water consumption amount of unit product, comprehensive water consumption and etc.

144.2.3 Analysis on the Component Parts of CEIS for the Lower and Middle Reach Industry

The lower and middle reach industry have the features of long industrial chain, supply chain management, and continuous growth of retrieving responsibility of the waste and old product. So, these industries pays great attention to the environmental management problems such as a product's life cycle green management, green supply management and product disassembling and recovery.

(1) Product life cycle environmental management. This is an analytical model of two dimensions. In it, the horizontal axis represents each phase of life cycle, which are designing, processing, packaging, marketing, using and retrieving; the vertical refers to the contents of environmental management in each phase, attributes of which include economic, technical, environmental, resource, energy and social.

(2) Green supply chain management. It aims to carry out the unified environmental management with perspective of supply chain, and it may solve the problems existed in process of a product's life cycle environmental management.

(3) Product disassembling and retrieving. This is one of the key points to build the circular economy index system, which will include product's disassembly, retrieval, recoverability and economy.

144.2.4 Review

We can see that, there are some common ideas and also differences parts about green management or environmental management between the upper, middle and lower reach industries. The common ideas are the basic patterns which are saving energy, lowering consumption, reducing emission and recycling waste with the objective to decrease the impact of production and consumption on environment. The different parts are, the degree of impact on environment and the role of basic patterns among the upper, middle and lower reach industries. In fact, the impact of the upper reach industry on ecologic environment is much greater the lower and middle reaches industry. The role of green supply chain management in the upper reach industry is relatively small owing to the short industry chain. On the contrary, green supply chain management is attached great importance on the research of the lower reach industry owing to the long industrial chain, and the idea of a product's life cycle green management is same as green supply chain management actually.

In addition, the problem of disassembling, retrieving and recycling of waste product is being emphasized more owing to the shortening of product's life cycle, a large amount of them need to be put into production as raw materials again. This reversal direction material flow promotes the relationship between the upper, middle and lower reaches industries. Thus, the upper, middle and lower reach industries, as three parts of manufacturing industrial chain, are being interrelated more and more under the linking and interacting of both positive direction and reverse direction material flow. It is another point to support the idea of building up a unified circular economy index system and embody the idea of transmitting environmental management.

144.3 Comparison Among the Circular Index Systems of Manufacturing Industrial Chain to Form into a Unified System

144.3.1 The Material Flow Relationship Among the Manufacturing Industrial Chain with Perspective of Circular Economy

The material flow relationship among manufacturing industrial chain with perspective of circular economy is shown in Fig. 144.1. In Fig. 144.1, the upper reach industry and the lower reach industry are connected through the middle reach industry and the vein industry to form the positive and reverse material flow. Both of the positive and reverse material flows are the components of value chain of manufacturing industry. It means manufacturing industrial chain under circular economy includes four parts. Based on Fig. 144.1, the key parts of circular economy in manufacturing industrial chain will be compared and analyzed, and a unified CEIS is appropriate for the whole manufacturing industrial chain then.

144.3.2 Comparison on the Key Works of Circular Economy Among Each Links of Manufacturing Industrial Chain

The key works of circular economy construction in the upper reach industry are listed as below. The first is energy saving. The percentage of energy consumption cost over the total product cost is great, which may reach 30–50 %. So, energy

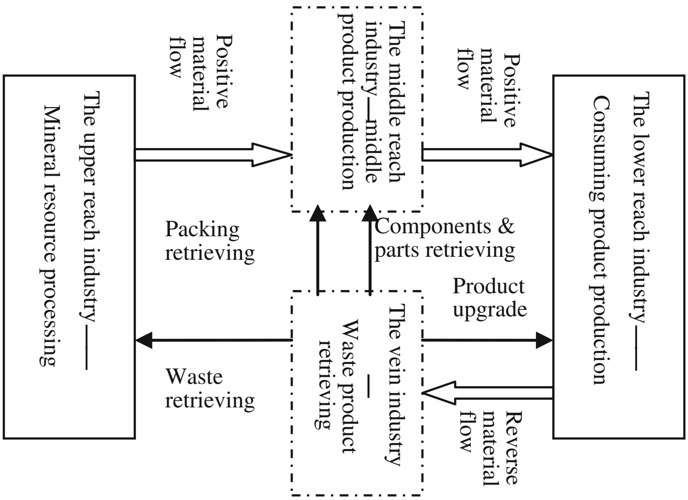

Fig. 144.1 Material flow chart of manufacturing industrial chain

saving is not only the need to cut the cost of a product, but also the requirement of the construction of circular economy and low-carbon economy. The second is emission reduction. That is to reduce three wastes emission continuously, including standard compliance and recycling. The third is consumption lowering. It refers to lowering the consumption of materials, especially the consumption of ore and fresh water.

The middle reach industry is the intermediate industry to connect the upper and lower reaches industries, which is somewhat vague in conception at the moment. Generally speaking, the kinds and scale of intermediate products will be more and larger with the higher degree of specialized production, and it means an improved industrialization level. The key works of circular economy construction in the middle reach industry are upgrade of intermediate products, energy saving, consumption reduction and old product recovery. For example, research and development of green energy motor is being paid great importance in many countries (Ye 2008). Integrated circuit plate is the main part to be recovered in the vein industry since it may be used to extract rare metals and as recoverable raw material. One carbon chemical products has good value of recovery.

The key works of circular economy construction in the lower reach industry is to give overall consideration on energy saving, emission reduction, consumption lowering and product retrieving or recovery in each link of a product's life cycle.

The vein industry is to disassemble and recovery many kinds of wastes materials into raw materials of industry. This industry is being developed rapidly in the advanced industrial area, and it has greater potential in future.

We can see that, the key points of circular economic work for all manufacturing industrial chain are same, which are the four basic works of energy saving, emission reduction, consumption lowering and waste reusing. However, the weight or function of each work in each industry differs greatly. The same key points are the basis to build up the unified frame of CEIS. The dissimilar working points may be reflected through choosing different circular economic index.

144.3.3 A Unified CEIS for Manufacturing Industrial Chain and the Component Index Selection

A unified circular economic index system for manufacturing industrial chain is built up on the basis of the industrial features and achievements made. The system is composed of energy consumption, material consumption, waste disposal and recycle in production, recovery of product and packing material, green design, and raw material production. The key indexes of circular economy for the four parts of industries have been selected primarily as shown in Table 144.1. In Table 144.1, part A and B are the basic parameters to be lowered for circular economy progress of manufacturing industrial chain; part C, D, E and F represent the controlling parameters in a product's life cycle. These parameters may be selected respectively for each reach industry.

144.4 The Problem of Environmental Management Transmitting Considered in the Unified CEIS for Manufacturing Industrial Chain

144.4.1 Weight Variable Setting Idea

This problem plans to be solved through setting up the weight variable shown in Table 144.1. For example, in the upper reach industry, the indexes of energy and material consumption, waste disposal and recycle have great influence, their value of weight variable will be big then; in the middle and lower reach industry, the indexes of product and packing material recovery, and product green design have great impact, so their value of weight variable will be large. The vein industry aims to retrieve, disassemble, classify and transmit wastes, so the weight of indexes of product and packing material recovery as well as the weight of electricity and water consumption, three wastes emission and treatment will not be small.

Suppose weight variable is W(X) = W{W1(X), W2(X), …, Wn(X)}, n is the number of index. In a industrial index system, Wi(X) $\neq$ 0, if it is the component part of the index system; Wi(X) = 0, if it is not the component part of the index system. Wi(X) will be bigger, if its contribution or influence is greater; Wi(X) will be smaller, if its contribution or influence is less. It means that the weight value of Wi(X) will be varied in different index system, and the weight value of Wi(X) may reflect its environmental management and transmitting status along the

Table 144.1 A unified CEIS for manufacturing industrial chain and the index selection

Index system composition		Weight variable	Index system for upper reach industry	Index system for lower reach industry	Index system for middle reach industry	Index system for vein industry
Energy consumption (A)	Electricity consumption	X1	√	√	√	√
	Coal consumption	X2	√			
	Gas consumption	X3		√	√	
Material consumption (B)	Raw material consumption	X4	√	√	√	
	Water consumption	X5	√			√
Waste disposal and recycle (C)	Waste water	X6	√			√
	Waste gas	X7	√			
	Solid waste	X8	√	√	√	√
	Waste oil Waste liquid	X9		√	√	
Product and packing material recovery (D)	Old product upgrade	X10		√	√	√
	Component part reuse	X11		√	√	√
	Waste material reuse	X12	√	√	√	√
	Packing material retrieving	X13		√		√
Green design (E)	Design for disassemble	X14		√	√	
	Design for recovery	X15		√	√	
Raw material production (F)	Mineral mining	X16	√			
	Raw material smelting	X17	√			
	Raw material purchase	X18		√	√	√

manufacturing industrial chain (upper reach, middle reach, lower reach and vein industry). For example, the energy consumption indexes A(X) and material consumption indexes B(X) have great influence in the upper reach industry, but its influence reduce gradually along the middle reach industry and lower reach industry. Waste disposal and recycle indexes C(X) all have great influence in the three reaches industries. Product and packing material discovery indexes D(X) have great influence in the vein industry, and have potential value in the lower reach industry. Green design indexes E(X) is considered only in the lower reach industry now, but it will be attached more importance gradually in the middle reach industry and upper reach industry. As to indexes F(X), there are several points to be noticed, that is, raw material production is the important part in the upper reach industry; raw material purchase is a channel to link each reach industry; purchasing environmental friendly products will meet the demand of transmitting unified environmental management.

The sum of all indicators weight is 1, that is $\Sigma Wi(X) = 1$, $(i = 1, \ldots, n)$. In Table 144.1, the number of composed indicators is varied, and the weight of the first class indexes is as below. $WA = W1 + W2 + W3$, $WB = W4 + W5$, $WC = W6 + W7 + W8 + W9$, $WD = W10 + W11 + W12 + W13$, $WE = W14 + W15$, $WF = W16 + W17 + W18$.

144.4.2 Weight Variable Model

Suppose the number of composed first class indexes in a CEIS for manufacturing industrial chain is n, and the number of composed indicators in each first class index (second index) is m. The weight of each index or indicator as well as probability and information amount embodied differs owing to the varied index number and varied indicators number. Therefore, combination of entropy coefficient method and the partial variable weight method is used to build up a weight variable model.

According to the partial variable weight method (Yao and Li 2000; Chen et al. 2009), suppose a indicator's variable weight vector Wj(X) is the Hadamard multiplication of the indicator's constant weight vector Wj and status variable weight vector Sj(X), that is, $Wj(X) = WjSj(X)/[\Sigma WjSj(X)]$, $j = 1, \ldots, n$. According to entropy definition, status variable weight vector (information entropy) $Sj(X) = -k\Sigma Pj{*}\ln Pj$, Pj is probability. If all probability are equal, information entropy has the largest value $k\ln n$. To make $1 \geq Sj(X) \geq 0$, take $k = 1/\ln n$. constant weight vector Wj may be obtained with specialist method or AHP method.

In this paper, the composition of first class index is the same though the indicator composition of different industry is not same. That is, for the first class index, we have, $Wij(X) = WijSij(X)/[\Sigma WijSij(X)]$, in it, i(first class index) = A, …, F; j (second class index) = 1, …, m.

Suppose entropy value of the item i index in the first class index system is Si(X) = −1/ln n *Σ(Pij*ln Pij), i = A, …, F, j = 1, …, m, then, the information weight of this index $S'i(X)$ = (1 − Si(X))/Σ(1 − Si(X)), and the revised index weight coefficient is Wi(X) = Wi $S'i(X)$/[ΣWi$S'i(X)$].

144.5 Conclusions

Manufacturing industrial chain includes the upper, middle and lower industries of manufacturing industry in general. Under circular economy situation, the vein industry will be put into industrial chain. A unified circular economy index system (CEIS) model for the whole manufacturing industrial chain has been established primarily. The four industries may build up their circular economy index system through selecting corresponding indexes and indicators. At the same time, the idea and way of transmitting the unified environmental management requirement along industrial chain through setting up the weight variable is discussed. Next step, a certain industry will be chosen to build up a unified circular economy index system for case study and for deep study with this unified circular economy index system model.

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Chapter 145
Strengthening the Construction of Logistics Parks and Promoting the Competitiveness of Logistics Industry

Sheng-fen Li and Qing Zhang

Abstract This paper analyzes logistics parks' necessity for logistics industry. Combining the description of the current situation of our country's logistics parks, some corresponding suggestions are proposed in order to promote the development of logistics industry.

Keywords Logistics parks · Logistics industry · Development · Suggestions · Logistics

145.1 Introduction

As a third profit source, Logistics can not only promote economic development, but also link up the enterprises of the supply chain effectively, so the government and enterprises pay more attention to it. And as a new format in the development of modern logistics industry, logistics parks in China have played an important role in improving logistics organizational level and intensive degree, integrating logistics resources and transforming the mode of economic development. Logistics parks are the gathering places to more than a logistics enterprise in the space distribution sites. It provides comprehensive logistics services of a certain categories and sizes. At present, the development of logistics industry in China is still in the first stage, so it's very need to integrate the existing logistics resources and logistics enterprises by the form of logistics parks.

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145.2 The Necessity of Strengthening the Construction of Logistics Parks

145.2.1 Main Functions of Logistics Parks

Logistics parks play many roles—intensive role, connected role and environmentally friendly role–in the development of the logistics industry (Wang and Yang 2001). Firstly, the intensive role can make sure the scattered goods and enterprises getting together. Of course, this is not enough, because it can also provide technology and management, so that we can use this kind of intensive role to organize the goods efficiently. Secondly, as a connecting part, logistics parks realize the connecting of different transports form of the highway, railway, aviation and port. Thirdly, as we all know, the environment is more important for we human being. A growing number of studies of the logistics industry have based on the environment, such as Low-carbon logistics (Chen and Lan 2011). Building logistics parks can reduce the times of the vehicle's travelling, as a result reducing noise pollutions and needless exhausts.

145.2.2 Necessity

Logistics parks set market information, modern warehousing, professional delivery, multimodal transport and market exhibition and trading in a body. At the same time, the repeated investment is avoided by gathering numerous logistics enterprises together to improve the resources' utilizations (Zhao 2011). As a demonstration project, logistics parks' mission is setting up the foundation platform and operation base of the modern logistics. It's good for the development of the logistics industry.

145.3 Current Situations of the Development of China's Logistics Parks

145.3.1 Present Situation

Since 1999 the first logistics park was found in Shenzhen, the great achievements of logistics have been made in our county. The situations of the development of China's logistics park are as followed:

a. Many kinds of types
   In our county, the logistics park can be divided into three kinds of business types. The first is distribution model which mainly depends on distributing

storing commodities in the internal city. The second is freight hubs type which can connect the transportations of the sea, land and air. The third is comprehensive parks which can offer a variety of logistics services for the enterprises. Among them the third is a popular one.

b. Geographic distribution
For some reasons–the distinct economic levels of different cities, the various demanding for logistics parks and the different conditions of infrastructure and so on–logistics parks present a characteristic of uneven region distribution (Xie 2012). The parks now mainly focus on the developed coastal area, demanding a great amount of things to be exchanged at the same time. While in the Midwest, the quantity of the logistics parks is relatively small, such as Qinghai province (Wang et al. 2007).

c. Incomes
Incomes of our country's logistics industry most come from warehouse, loading bays of rent, supporting facilities rental and management fees, property management fee, office building rent. Only a handful of logistics parks get benefits from information service, warehousing and distribution of profit value added services. What's more, there are a few logistics parks make money by the way of braking preferential tax and landing lease or selling against income. These show that the channel our country's logistics parks' income source is relatively single, and the facts of management service added value is not high and low profitability.

145.3.2 Problems

With more than 10 years developing, the total number of the logistics park has surpassed the abroad countries'. But in essence, there is a real large gap, especially compared with developed countries in the logistics industry, such as Japan, Germany and the United States. Then we have the opportunity to find some problems existing in the logistics park.

a. Lack of planning and cooperation
In practice, our country's logistics park is still fragmented, intersected and divided (Huang and Ge 2010). These parks cannot produce a linkage between utilities, because they consider things just from administrative regions or even a single logistics park, but not the impacts it can produce among the economic regions it radiates (Wu and Ju 2011). What's worse, the require of different regions for the logistics park is not the same, so various kinds of parks appeared leading to the results of repeating investment on the logistics infrastructure, competing with each other on low level and wasting a lot of resources (Xu 2011). This phenomenon, on one hand, is caused by the lack of overall planning. On the other hand, it can be attributed to share information with each other inefficiently. In my opinion, lack of the mechanism of sharing information

is the main reason so that these parks cannot be cooperative interaction. It's important to play a role of network system for the isolated parks and to be a node for the regional logistics network system.

b. Pursuing for quantities and perfection blindly
With the development of the economic, the logistics industry thrives and the logistics parks are buildup quickly. At present, the total number of our country's parks has been growing quickly, while the quality is beyond our imagination (Abrahamsson et al. 2003). In the logistics park's planning and construction, we'd better think of the actual needs of the cities and avoid pursuing for quantities blindly.

c. low standard business
Most of the domestic logistics parks' logistics services are limited to provide warehouse and logistics equipment and lease loading bays rent. There is not much different from the traditional storage property and these services can not meet the different demands of these customers. What's worse, because of crude facilities, low quality of employees and low level informatization, the park can't offer high added value services for multinational companies and other high-end customers causing that the park service does not match the supply and demand.

145.4 The Way to Strengthen the Construction of Logistics Parks

145.4.1 Strengthening the Government's Influence and Function

It's the government's macro planning and strict examination that is crucial for the development of the logistics park. In china, so far, the national logistics park has not been formed. While only a few regions formulate the regional logistics plan. Compared with China, Japan and Germany do a better job, so it's wise for us to learn them. In Japan, the government divides the parks into three levels–macro plan, medium promoting and micro operation. What's more, each level's emphasis and responsibilities are very clear and definite. Usually, a plan of the comprehensive logistics policy points out all the cities' needs to build a park in macro angle. Then according to the urban plan, the local government decides the locations, quantities, scales and functions of the logistics park and submits the decision to the central competent secretary for examination and approval. Only in this way can the parks be constructed (Xia 2011). In Germany, in 1992, the federal government made the plan of establishing 28 parks within the territory of all the Germany. After 3 years later, according to the present situation of the development of the logistics industry, the number of the parks changed from 28 to 39. The logistics network formed by connecting with the ground traffic systems and information systems (Yu 2011). From their experience, I suggest that our government should combine with its own resource advantages or location advantage to strengthen the construction of logistics parks and improve logistics parks' management. On one hand, we'd better pay attention to the unified planning and the supporting policy. On the other hand, we'd better take optimizing the development of the logistics park into account and pay special attentions to the integration of the existing logistics enterprises.

145.4.2 Improving the Concentration of Logistics Industry

One of the logistics park's function is, in a certain extent, linking the enterprises on the value chain together. It can not only make full use of the enterprises' expertise and advantages, but also enhance each enterprise's connection on the value chain. The most important thing is that it benefits to the cost saving by promoting the information exchange between them (Li and Liu 2011).

Improving the concentration of logistics industry can help information be exchanged among these enterprises. If the enterprises on the supply chain exchange information more conveniently and cooperate more closely, the cost of trade between enterprises will be greatly reduced. What's more, a logistics enterprise can give full play to its own core business. As for its own weakness and inferiority, the other enterprise may make up. In this way, a great of drawbacks not professional may be avoided and the logistics park will become an organic whole. If all this will come true, a good logistics park should be build up because it can attract this enterprises on this value chain get together to realize its value.

145.4.3 Establishing a Public Information Platform

With the development of the internet, a public information platform is required. It can provide and integrate the information of every link of the supply chain. It can also provide management service, technical service and trading services.

If the Logistics parks want to strengthen their competitive ability, it will be better to promote the establishment of public information platform. It calls for a lot of technology such as Bar Code, Electronic Ordering System (EOS), Quick Response (QR), Database, Electronic Data Interchange (EDI), just-in-time (JIT), Effective Customer Response (ECR) and Enterprise Resource Planning (ERP) and so on. For example, with the thought of the just-in-time (JIT) getting popular, enterprises' business processes are also adjusted accordingly. Formerly, the commodities was distributed according to enterprises or governments, this is the so called Push model, whereas, now is according to the demands of the customers or markets, in other words pull model. This new model can guarantee that the enterprises make rapid responses just in the needs of the customers. It can immediately organize the order and sent the goods to the customers effectively, thus reducing inventories and the avoidable wastes. From this we know the use of the JIT, ECR and POS and so on can make contributes to the development of the logistics park and the logistics industry.

Information is the foundation of all things but the technology is the tool to make sure of delivering information smoothly, so we'd better learn these technologies patiently. Information technology has become one of the important components of the core competitiveness of the enterprises. For one thing, modern logistics emphasizes the sharing, collecting and transmitting information resources quickly and accurately. For another thing, with the aid of the information technology the decision maker can make some decisions well and truly.

145.4.4 Encouraging Enterprises Coming in the Parks Positively

The ultimate goal of logistics parks is serving for enterprises in the park. If the logistics parks want to attract corporate coming in, the rules of the access should be made at the early stage, meanwhile a series of preferential policies should be established. During the Twelfth-Five Year Plan period, the logistics industry will face more opportunities.

145.5 Conclusion

Above all, logistics parks are a kind of development model, a space concept and a logistics node of high standard. At present the logistics industry in China is still in the first stage, needing to adopt the form of logistics parks to integrate the existing enterprises and their resources (Wang 2011). So it's obvious that developing logistics parks will become our country's inevitable trend in the future, as well as the best point and combining site for government and enterprises to jointly promote the development of logistics.

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Chapter 146
Constructing Agricultural Products Logistics System to Ease Inflationary Pressure

Xing-guang Li, Hai-juan Zhou and Tie-sheng Wang

Abstract Sophisticated logistics system will effectively reduce the terminal price of the goods. The existence of the enterprise since for logistics, cold chain imperfect, inefficient distribution, lack of information, asymmetric information, and many other issues lead to China's social logistics costs, especially in the high logistics costs of agricultural products and fruit and vegetable products, and also result in China's CPI rising. From the characteristics of the agricultural product logistics and the development of the current situation, combined with the logistics of the actual situation of China's agricultural products, this article constructs the mode of operation of agricultural products based on the theory of supply chain logistics, and gives the policy suggestions of how to effectively improve the logistics system of agricultural products, agricultural products circulation and reduces the circulation cost, slow inflation pressure.

Keywords Agricultural products logistics · Supply chain theory · Operation mode

146.1 The Overview of Agricultural Products Logistics

Taking agricultural products as the core, the agricultural products logistics refers to the organic combination of the entity flowing from producer to receiver and the involving technology, organization, management and other basic functions.

Subject source: Hengshui University teaching reform issues (jg2012056). Li Xingguang (1981–) male Hebei Zaoqiang Hengshui University research direction: logistics system engineering. Zhou Haijuan (1981–) female Hebei Qian'an Hengshui University research direction: Marketing Assistant. Wang Tiesheng (1965–) male Hebei Hengshui Hengshui University Professor research direction: the social and economic.

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It consists of a series of links, such as agricultural production, purchase, transport, storage, loading and unloading, handling, packaging, distribution, circulation processing, information activities, and etc. and realizing agricultural product appreciation and organization objectives in the process. (of agricultural logistics: Source-Baidu Baike).

Agricultural product logistics has three big characteristics.

146.1.1 Large Quantities and More Varieties

According to our country 2011 statistics show: grain output reached 546471000 tons, 5961000 tons of cotton, oil plants 32301000 tons, 214011000 tons, 110789000 tons of fruit sugarcane, 9296000 tons of beets, 1475000 tons of tea etc.

146.1.2 High Demanding

Different from the industrial products, the agricultural products are living animal and plant products, so the agricultural product logistics especially demands green logistics to achieve no pollution, no deterioration; owing to the agricultural product prices low and large volume, low operation cost must be accomplished; due to the circulation of agricultural products to ensure and increase the income of the farmer, in developed countries, agricultural products and agricultural products processing production value is 1:3 or 1:4, and our country is 1:0.8, the development of large space (Li and Zhouhai 2009).

146.1.3 Difficult in Material Flowing

It manifested chiefly by packaging, transport, storage hard, difficult to store. Because the agricultural products are perishable, certain measures are necessary in circulation in order to ensure that the products meet the quality requirements to enter the field of consumption. This resulted in its infrastructure, storage conditions, transportation, technology and other means to have corresponding organization for applied (Li and Zhouhai 2009).

146.2 The Current Situation of Agricultural Product Logistics in China

Logistics in our country starts late, the foundation is weak, the amount of the agricultural products logistics is huge, supply is dispersed, cost is very high. After the development in recent years, China's agricultural product logistics system is gradually improving, but is still in the stage of practice. There are still a lot of self-produced self-marketing and hawker small and primitive agricultural products logistics form. At the same time, the cold chain of China's agricultural products complexes with lower coverage, circulation loss is large, a certain extent increase the circulation cost, and cannot meet the needs of consumers in general. Embodied in the following aspects.

146.2.1 Poor Infrastructure, Low Levels of Information Technology

In China, the construction of wholesale markets for agricultural products, agricultural products storage, transport conditions and tool, the information network platform and other public facilities are lagging behind, resulting in high cost of the circulation of agricultural products circulation and low efficiency. Being the small-scale intensive cultivation of business, the way that farmers of our country acquire the agricultural production information mainly rely on traditional methods, related logistics information network system is not perfect, the serious information asymmetry increases the risk of agricultural products (Han 2007).

146.2.2 The Cost Lag the Agricultural Products Cold Chain Development

With the improvement of living standards, consumers pay more attention to the freshness and variety of the fresh agricultural product. Although the cold chain transport is one of the most important links in guaranteeing freshness and varieties of fresh agricultural product in the circulation, the cold chain logistics system has not nearly been established yet, the coverage rate of cold chain of fresh agricultural products is less than two percent. Cold chain transport deficiency may also cause bigger loss in the transport, increasing the logistics cost.

146.2.3 Current Node, Produce and Sale is Out of Line, Prices Fluctuate Wildly

Nowadays, it was taken as usual that "the farmer found that the food is hard to sell, the residents felt that the food is expensive, and the brokers said they hadn't earn money". At present our country agricultural product circulation system remains around the "agricultural and sideline products wholesale market", agricultural products pass from producers to consumers through four links including from farmers to the wholesale market, transport from production to marketing, from the wholesale market to retail terminal, there will be the occurrence of packaging costs, fuel costs, the market management fee, freight, entrance fee, overload fines, etc. in this process, ultimately reflected in the terminal 's vegetable prices rose sharply. Therefore, to establish the system of the agricultural product logistics, reduce the links from fields to the common people table segment.

146.2.4 Agricultural Product Circulation Industry

Agricultural product circulation industry is still in extensive management level, relying on science and technology innovation to promote the industrial added value is not obvious. And the western developed countries are to accelerate the innovation of agricultural technology, using the "Internet of things" and other techniques to enhance the labor productivity.

In addition, a problem that cannot be ignored remains in the construction of agricultural products market, these serious problems are plaguing China's modern agricultural products logistics industry development (Fig. 146.1).

146.3 The Agricultural Product Logistics Operation Mode Based on Supply Chain Theory

From the perspective of supply chain theory, logistics cooperation organizations can improve logistics efficiency and avoid the higher organization cost. Pure market mechanism in reality is influenced due to the factors, such as technical conditions, geographical conditions, market risk, repeated transactions, transaction

Fig. 146.1 The agricultural product logistics operation mode based on supply chain theory

costs increase, market efficiency discounts (Li and Zhouhai 2009). Logistics alliance formed through the market organization to reduce free market transaction cost is a kind of system form. Logistics operation pattern constructing based on the theory of supply chain of agricultural products is the changes of agricultural product transaction way, means or procedure, its power is to save the costs of the logistics organization of agricultural products trade and internal management external transaction, to improve the overall efficiency of the logistics of agricultural products.

The structure of agricultural product logistics operation mode based on the theory of supply chain products logistics service; agricultural products market is the sale of wholesale market (Wang 2009).

Agricultural Cooperation Organization plays the frame supporting role in the whole system. It needs to complete the two aspects of work:

1. Establishing contact with farmers. In the scale of economy, developing a certain number of farmers into agricultural cooperation organization, collecting farmers' demands regularly for logistics information, and be responsible for information integration and analysis.
2. Establishing contact with the third party logistics enterprises. Picking logistics enterprise according to certain standards, keep the contract, and supervise the performance of the agricultural product logistics enterprises.

The advantage of supply chain of agricultural products logistics operation mode is based on the theory.

The model brings many beneficial effects for the parties, and can expand agricultural production scale and diversity management, achieve economies of scale and scope economy effect.

The agricultural product logistics system is the supply chain whose core is an agricultural cooperative organization, its core enterprise (Agricultural Cooperation Organization) goal is to make the farmer average minimum logistics cost, it stands from the farmer's point of view. The relationship of the third-party logistics companies and agricultural collaboration is contractual, through information collection and operations integration of the agricultural cooperative organization, logistics demand and supply of parts into a whole, improving the efficiency of logistics operations and greatly reducing the average cost of logistics (Wang and Huang 2005).

146.4 The Proposal of Optimizing Agricultural Product Circulation

Through constructing the agricultural products logistics system based on the theory of supply chain, we can effectively realized that agricultural production and economies of scale, reduce current cost, and effectively alleviate inflation pressure. Specific recommendations are as follows:

1. Play the government's regulating and controlling role. (Xu 2006). The government management should take it serious, set up a special leading group, lead to clear the agricultural product circulation channel, establish a highly efficient, safe, expedite the modern circulation system of agricultural products in 3–5 years.
2. To build the logistics of agricultural products trading center in larger city, innovate in technology, management, supply and demand, platform construction, and other aspects comprehensively (Wang 2007), carry out e-commerce, traceability, and trade crossing the transaction time, regional distribution. At the same time, the government should reduce the field of agricultural and sideline products trading threshold, the tax relief, to large-scale logistics enterprises give on policy tilt.
3. Establishment of agricultural early warning system. Government departments can make general agricultural product price forecasting index according to season and regional production, planting area and oil price, means of production, the price of labor, form an integrated, for farmers to provide reference, so as to ensure market supply and price stability. (Fan 2011).
4. To train a batch of bibcock enterprise, drive the development of agricultural products (Fang 2004). Make more farmer agent active in field edge of a field, become a farmer and logistics between the go-between; promote agricultural products modern logistics technology innovation ability, improve the construction of Internet of things, cold chain infrastructure construction, let consumer eat to be at ease, fresh agricultural products.

146.5 Summary

According to the characteristics of the agricultural product logistics, the logistics of agricultural products in our country's present situation, introducing Agricultural Cooperation Organization (Logistics Alliance) as the core enterprise in supply chain of agricultural products, based on the theory of supply chain of agricultural products logistics operation mode, for the development of agricultural products logistics mode to provide reference model, and the control of agricultural products price inflation pressures gives policy suggestions. With the development of modern logistics theory and agricultural products are as soon as possible, and to establish a highly efficient logistics operation mode of great significance.

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Chapter 147
Research on Environmental Logistics Distribution Problems

Li-hong Yao, Xiao-ping Guang and Yang Yang

Abstract With globalization of economy, logistics is closely related to our life, especially environmental logistics improves traditional logistics. Based on the concept of sustainable development, environmental logistics achieves the aim of environmental protection and make the best of recourses by applying advanced technology and improve each link of traditional logistics, especially distribution. Environmental logistics distribution has many different modes, many factors should be considered to achieve distribution optimization. Finally the research puts forward advice for the development of environmental logistics distribution in the future.

Keywords Environmental logistics · Distribution · Distribution optimization · Distribution system · Suggestions

In order to achieve some benefits, traditional logistics enterprise operators only pay attention to the efficiency of goods flow, however, it often ignores the protection of the environment. Materials bring negative effects to the traffic and environment in the process of circulation. Modern logistics is no longer at the expense of the environment, should advocate of environmental and sustainable development of the logistics concept. In the twenty-first Century, environmental logistics is the direction and trend of logistics development. Environmental logistics is a new logistics management mode including forward logistics and reverse logistics. Recycling and reproduction consumer products realize the goods recycling and secondary utilization, thus the reverse logistics emerged. Reverse

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logistics rational uses existing resources by the resources integration again, and achieve the purpose of reducing pollution to the environment.

Make use of advanced logistics transportation equipment and management technology, planning and implementation of transportation, distribution and logistics activities, environmental logistics realizes logistics transportation links in harmony with the natural environment development, really achieving sustainable development (Peng 2004; Gong and Ying 2005).

147.1 Content and Characteristics of Environmental Logistics

147.1.1 The Content of Environmental Logistics

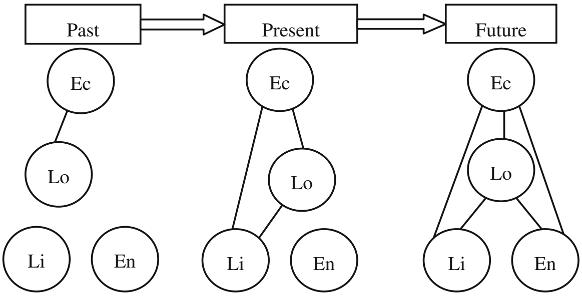
Environmental logistics refers to inhibiting harm to the environment during the process of logistics and realizes the purification of the logistics environment and makes the best use of logistics resources at the same time. Figure 147.1 shows the relationship among economy, logistics, life and environment (Yang and Zhang 2002). In the figure, Ec presents economy; Lo presents logistics; Li presents life; En presents environment.

147.1.2 The Characteristics of Environmental Logistics

First, symbiotic relationship between environmental logistics and ecological environment protects the environment and pulls of sustainable development of social economy environment.

Second, economization. In our life, excessive raw materials are unnecessary waste, products are stored in the warehouse because supply exceeds demand, which eventually lead the products obsolescence and loses the original product value.

Fig. 147.1 Relationship among logistics, economy, life and environment



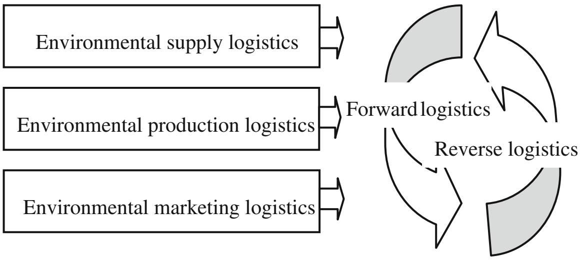


Fig. 147.2 Constitutional diagram of environmental logistics

In the field of production, consumption and distribution of all kinds of waste phenomenon exist everywhere.

Third, circulation. The product recovery is a very important link to secondary utilization of waste materials. The renewable resources recycling, such as raw materials regeneration, recycling of waste materials and so on, is all that environmental logistics should consider. It is such a need that forms reverse logistics (Song 2010).

Figure 147.2 shows that environmental logistics contributes to logistics and reverse logistics.

147.1.3 Rationale About Environmental Logistics

a. Sustainable Development of Environmental Theory
   From the view point of environmental protection, a very good coordination among the economy, society and environment is needed to form a logistics system symbiosis with the environment, reduce or even eliminate the harm to the environment.
b. Ecological Ethics
   From an ethical perspective, people should establish a friendly relationship, not regard the nature as an object for exploitation, protect nature, love nature, and pursue the whole balance between mankind and natural. Ecological ethics theory's ultimate goal is to pursue the maximum benefits of the whole, reducing natural exploitation and interference between human and nature, to realize harmonious development.
c. The Theory of Ecological Economics.
   Economic interest means the maximization of benefit. But ecological economists pursue the economic benefit, social benefit, environmental benefit, ecological environment and economy to coordinate develop.

The theory of ecological economics mainly studies the relationship between ecological system and economic system. How to better realize the ecological system and the economic system coordinated development is the main goal of ecological economists (Qin 2005; Huang 2010).

147.2 Structural System Research About Environmental Logistics Distribution

147.2.1 The Content of Environmental Logistics Distribution

Environmental logistics, in our national standards "*logistics terms*" is defined as inhibition to causing harm to the environment in the process of the logistics, realizing the purification of the logistics environment and making the best use of logistics information (Hu et al. 2006) at the same time. The distribution is, defined as according to user requirements, chose, process, pack, classify, match and send articles to the designated locations of logistics activities on time as economically and rationally as possible (Qi 2007).

Environmental logistics distribution is mainly composed of environmental transportation, environmental packaging, environmental handling and transporting, environmental stock and environmental distribution processing subsystems.

But in the subsystems there exist serious environmental problems, it is necessary to formulate environmental policy and planning, perfect laws and regulations, and for staff to receive environmental education.

147.2.2 Research on the Mode of Environmental Distribution

a. Reverse Logistics
   Reverse logistics perfects traditional forward logistics based on the logistics mode of circular economy. Circular environmental logistics mode is "environmental raw materials acquisition, environmental production, environmental consumption, environmental recycling and environmental reproduction". This process includes raw materials by-product recycling, green packaging recycling, waste recycling, garbage collection and recycle.
   Reverse logistics recycles value and surplus value commodity to reduce waste. On the other hand, it saves raw materials also brings certain economic benefit by the product updating, assembling recycling products into new products. Development of new technology makes the products' secondary utilization available.
b. Joint Distribution
   Joint distribution is a partnership between distribution companies and distribution companies, or between distribution center and distribution center, to obtain the intensive operation mode.
   Joint distribution can avoid the enterprise waste transport vehicle and resources, because of a small portion of the user's needs, more and more companies send goods just in time, even the car is not fully loaded.

To take full advantage of enterprise resources is necessary. Originally many enterprises operate independently to complete their respective distribution tasks by a lot of cars, but now they only need a car, or a small amount of vehicles. Thus, it saves vehicle resources, on the other hand, decreases traffic pressure and traffic congestion.

3. Third-Party Logistics (3PL)
   Enterprises outsource logistics business to professional logistics companies but mainly focus on the development of enterprise's own products and their function and characteristics, so that the products on the market are more competitive.
   Third-party logistics is neither logistics supplier nor logistics buyer but provides professional logistics services, logistics operation and management. Third-party logistics refers to external service providers that provide some or all of the logistics function. It is a form of logistics professionalization.
   The services of third-party logistics includes logistics system design, storage, information management, consultation, stock of goods and agents (Ru and Song 2005; Luo 2007; Lu 2007).

147.2.3 Factors of Environmental Logistics Distribution Solution

Distribution is one of the most important parts in the process of logistics. To achieve environmental logistics distribution, some factors should be considered, it takes advantage of enterprises and traffic, even environment.

a. Shortest Shipping Distance
   Shipping distance is in proportional to the distribution cost, namely, the longer the shipping distance, the higher the transport cost.
b. Fastest Shipping Speed
   One of the main factors customer evaluate distribution service level is punctual whether it is or not.
c. Lowest Shipping Cost
   The biggest benefit for enterprise is a common object for business. The enterprise reduces the cost equally to increase the effectiveness for the enterprise.
d. Least Shipping Consumption
   Distribution involves vehicles, personnel, fuel and equipment. Rational allocation of vehicles can decrease vehicles and drivers to save labor. Fuel consumption and equipment saving, in the process of transporting should be taken into account.

The essence is a multi-objective optimization problem, we generally regard multiple target simply as single objective problem (Guan 2007).

147.3 Measures and Suggestions About Establishing Environmental Logistics Distribution System

147.3.1 Strengthen Environmental Logistics Infrastructure Construction

Infrastructure is the foundation and safeguard for logistics normal operation.

Perfect function, reasonable layout logistics infrastructure is conducive to promoting the construction of environmental logistics system and contributes to the healthy and fast development of environmental logistics. Environmental logistics infrastructure development is progressive, systemic and resource integrated characteristics. Environmental logistics infrastructure construction is divided into three stages: to construct demonstration project, to promote environmental logistics infrastructure system construction, and to improve environmental logistics infrastructure system.

Then, plan and coordinate environmental logistics infrastructure. Whether to integrate the existing facilities and comprehensive utilization, or plan and coordinate the newly-built facilities, or accomplish facilities the reasonable layout and perfect function according to the development view of comprehensive, coordinated, sustainable development advance (Ke and Wang 2005).

147.3.2 Construction of the Environmental Logistics Transportation System

In addition to good use of existing three kinds of transportation modes, we need to positively innovate new transport mode. Transportation cost is an important part of logistics cost, a successful logistics distribution system can not be separated with high efficiency, quick response ability, low transportation cost transportation network. Transport network design is a strategic decision, decision makers need to be aware of goods flow, network connection and node structure of the whole supply chain. So optimizing transportation route is also very important (Xi and Liu 2010).

147.3.3 Institutional Innovation

First, it is incentive mechanism including green subsidy policies, preferential tax policy and government procurement policy and so on.

In order to promote the development of environmental logistics, the government must establish effective environmental incentive policy. This kind of incentive policy is mainly through economic levers to inspire and guide the behavior of main logistics companies (Wang and Wang 2011).

And then the government system should include environmental institution and charging institution. Government system can make up for the lack of incentive mechanism binding. The advantage of government system is definite goal, the mandatory implementation and direct effect.

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Chapter 148
Analysis of Risk Dependencies in Project Supply Chain

Chun-dong Wan, Wen Tang, Jun Sun and Qing Li

Abstract Project supply chain is a large scale system, risks are not always independent, and the weakest link in the system can lead to increased vulnerability for all partners in the network. We believe that explicitly identifying and managing risk dependencies would be critical during the whole risk management process. This research analyze two risk dependency types: risk dependencies between two risks and combined risk interactive when there are more than one risk element affecting the other particular risk. As risks can bring losses and opportunities to a project supply chain, we define the opportunity possibility of the risk conducting effect.

Keywords Project supply chain · Risk factors · Risk interdependencies · Risk research

148.1 Introduction

Project supply chain is an example of an interactively complex socio-technical system that spans multiple organizational entities. Due to a large number of interrelated processes and products, disruptions caused by these vulnerabilities propagate rapidly (Tah and Carr 2001; Utne et al. 2010). And project supply chain members do not have a shared understanding of issues facing the project, are not able to implement effective early warning systems and contingency plans to adequately deal with problems resulting from decisions taken elsewhere in the chain (Arshinder et al. 2008; Stank and Arango 1999; Jukka et al. 2002). Risk

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dependency is meaning an effect caused by a risk and its effect can either increase or decrease the occurrence of other risks (Kwan 2009).

The paper aims to analyze the dependencies of risk factors in the project supply chain. As risks conduct across the project supply chain, the risk factor also is affected by other risk factors coming from the same project phase or other nodes. So in this case, it is very necessary to know the risk metrics of the specific risk dependencies. The paper is organized as follows. We start with the literature review analysis. In Sect. 148.3, we give the risk dependency metrics. In Sect. 148.4, we describe the case when one risk is affected by more than one risk. Section 148.5 describes the favorability of risk dependency in project supply chain.

148.2 Literature Review

As to the dependency relationship between risks, there are several dependency analysis models which have been used to represent the dependency of one event on another.

Three tree-based (Aven 1992) analysis methods are reviewed here. Fault tree is a logical diagram used in the Fault Tree Analysis to represent the possible cause of an undesired event. A fault tree can tell the relation between the failure of a system and failures of the system component (Aven 1992). Event Tree Analysis is a method to illustrate the sequence of possible outcomes after the occurrence of an undesired event. The event tree can be used for both qualitative and quantitative analysis. Cause-consequence analysis combines the FTA and ETA, and is performed with a cause-consequence diagram, which starts from an undesired event and develops backwards to find the causes and forward to find the consequences. CCA can help to find the chain of events from the initiators of an undesired event to its final results.

Markov analysis provides a mathematical method to analyze the reliability and availability of systems, which are specified and have strong component dependencies. In this analysis, a system is modeled as a number of discrete states with possible transitions among the states (Kwan and Leung 2009). As to the tree-based analysis, Markov analysis does not require component independence and an acyclic structure.

Bayesian network is a directed acyclic graph in which each node represents a variable and each arc represents causal or probabilistic influential relationships between variables. A link between two variables represents a probabilistic dependency between them. A Bayesian network can be analyzed qualitatively or quantitatively. When a Bayesian network is analyzed qualitatively, it provides the relations between causes and effects of nodes. If a Bayesian network is analyzed quantitatively, it is a description of a joint probability distribution, in which each node is associated with a conditional probability distribution reflecting its parent nodes (Fenton and Neil 2001).

148.3 Risk Dependency

When talking about risk management, we often treat risk factor independently, but all things in the universe are closely interrelated with one another. For the participants in the project supply chain, they are united together under different project stages, and risk factor in one stage will conduct to the next project stage. The increasing and decreasing of risk in this way will eventually change project performance. As project team members adopt different terminology for describing risks, use different methods and techniques for dealing with risk analysis and management, producing different and conflicting results. With the increasingly complex and dynamic nature of projects coupled with new procurement methods, the tendency nowadays is to use risk quantification and modeling more as vehicles to promote communication, team work, and risk response planning amongst multidisciplinary project team members (Hyatt and Rosenberg 1996).

148.3.1 Risk Dependency Value

For any two identified risks in a given set of risk factors, R_a and R_b, if Ra causes R_b occur, we write $R_a \rightarrow R_b$. For any two risks, R_a and R_b, there could be three possible relations between them (Kwan and Leung 2008):

(1) $R_a \rightarrow R_b$ or $R_b \rightarrow R_a$, $R_a(R_b)$ affects the occurrence of $R_b(R_a)$
(2) $R_a \Leftrightarrow R_b$, R_a and R_b affects each other.

We all know that each risk has two attribute, the probability P and the Impact I, say $R_a \rightarrow R_b$, if R_a happens, the risk conducting effect will affect the probability and result of R_b. We believe that, if this impact result assumptions are made properly, the impact result of R_b will also thought of the affect result of other risks. In this case, we can look the risk conducting effect as probability conducting as it has the effect on probability, and there is positive and negative effect both. Here are two methods to describe the affect result of the probability of one risk to the other one, called the risk dependency value and the risk dependency multiplier.

Here is a set of identified risks $R_1, R_2, \ldots, R_x$ *at a period and* $|R(t)| = n$, $R_x \in R(t)$, $R_x = f(P_x, I_x)$, *and* $1 \le x \le n$, $P_x \in P$ which is the possible probability values. If R_b has the only risk input or predecessor factor R_a, $R_a \rightarrow R_b$, and R_a, $R_b \in \mathrm{R(t)}$, $\mathrm{R_a} \neq R_b$, *there exists a Risk Conducting Value* D_{ab} *of* R_a *and* R_b (Kwan and Leung 2008):

(1) $D_{ab} = 0$, R_a and R_b do not have any dependency relationship
(2) $D_{ab} \neq 0$, R_b is risk dependent on $\mathrm{R_a}$
(3) $D_{ab} > 0$, R_a can increase the probability of R_b
(4) $D_{ab} < 0$, R_a can decrease the probability of R_b.

148.3.2 Risk Dependency Multiplier

Here is a set of identified risks $R_1, R_2, \ldots, R_x$ at a period and $|R(t)| = n$, $R_x \in R(t)$, $Rx = f(P_x, I_x)$, and $1 \leq x \leq n$, $P_x \in P$ which is the possible probability values. If R_b has the only risk input or predecessor factor R_a, $R_a \rightarrow R_b$, and $R_a, R_b \in R(t)$, $R_a \neq R_b$, there exists a Risk Conducting Multiplier DM_{ab} of R_a and R_b (Kwan and Leung 2008).

$$R_b{}^{+a} = f(P_b DM_{ab}, I_b) \text{ and } P_b DM_{ab} \in P \tag{148.1}$$

The Risk Dependency Multiplier DM_{ab} has the similar effect as D_{ab}, $DM_{ab} \leq (1/P_b)$. *DM_{ab} has the following attributes*:

(1) $DM_{ab} = 1$, $R_b^{+a} = 1$, $R_b^{+a} = R_b$, there is no risk conducting effect between R_a and R_b.
(2) $DM_{ab} = 0$, *then* $R_b^{+a} = 0$, the occurrence of R_a will eliminate R_b.
(3) $0 < DM_{ab} < 1$, $R_b^{+a} < R_b$, *the occurrence of R_a will lower the probability of R_b.*
(4) $DM_{ab} > 1$, *then* $R_b < R_b^{+a}$, *the occurrence of R_a will increase the probability of R_b.*

The conducting multiplier DM_{ab} is related to risk dependency value D_{ab} and P_b, we can get $P_b + D_{ab} = P_b DM_{ab}$,

$$D_{ab} = P_b(DM_{ab} - 1) \tag{148.2}$$

$$DM_{ab} = 1 + D_{ab}/P_b \tag{148.3}$$

148.3.3 Relating D_{ab} and DM_{ab} Using the Liner Method

In the Linear method (Boehm 2002), a risk is calculated by multiplying the Probability and Impact values. $R_b = f(P_b, I_b) = P_b I_b$, the P is a real value between 0 and 1. So if $R_a \rightarrow R_b$, R_b^{+a} will have the following equation:

(1) $R_b^{+a} = f\ (P_b + D_{ab},\ I_b) = (P_b + D_{ab})\ I_b = P_b\ I_b + D_{ab}\ I_b = R_b + D_{ab} I_b$, $P_b + D_{ab} \in P$ *and* $0 \leq P_b + D_{ab} \leq (1 - P_b)$
(2) $R_b^{+a} = f(P_b DM_{ab}, I_b) = DM_{ab} P_b\ I_b = DM_{ab} R_b$ *and* $P_b DM_{ab} \in P$, $0 \leq P_b DM_{ab} \leq 1$, *so* $0 \leq DM_{ab} \leq (1/P_b)$.

As to the method of Conditional Probability, $P(b|a) = P_{ab}/Pa$, P_{ab} is the joint probability of R_a and R_b, also $P(b|a) = P_b^{+a} = P_b + D_{ab}$, so P_{ab} has the following equation (Jukka et al. 2002):

$$P_{ab} = P(P_b + D_{ab}) = P_a(P_b + P_b(DM_{ab} - 1)) = P_a P_b DM_{ab} \tag{148.4}$$

So we can say, the risk conducting Multiplier DM_{ab} is equal to the joint probability of R_a and R_b divided by the multiplication of their two independent probabilities,

$$DM_{ab} = P_{ab}/P_a P_b \tag{148.5}$$

148.3.4 Relating D_{ab} and DM_{ab} Using the Ranking Method

There is another method using to calculate the risk value, the ranking method. A risk value is determined by applying a predefined table-based ranking. Each risk has the two elements (P_x, I_x). Assuming that a relative scale, *1* to *i*, is assigned to the probability values, thus the probability can take on a value between *1* and *i*, given $R_a \rightarrow R_b$, we can have the following equations:

$$R_b{}^{+a} = (P_b + D_{ab}, I_b) \tag{148.6}$$

And $P_b + D_{ab} \in P$ *and* $1 \leq P_b + D_{ab} \leq i$, *we will get*

$$(1 - P_b) \leq D_{ab} \leq (I - P_b) \tag{148.7}$$

There are also two other assumptions for this ranking method about D_{ab} (Kwan and Leung 2009):

(1) $D_{ab} > i - P_b$, $R_b^{+a} = (i, I_b)$, *as i is the biggest possible likelihood value*; *in this case*, *the risk conducting effect will not increase the probability value any more when the probability value has already reached its maximum.*
(2) *If* $D_{ab} < -P_b$, $R_b^{+a} = 0$. *The happening of* R_a *has already made* R_b *disappear*; *the risk dependency will not decrease the probability value any more.*

148.4 Combined Risk Dependency

In this part, we will consider when there are more than one risk affects a particular risk. By using three approximation methods (Pang 2008), called the Conservative Method, the Optimistic Method and the Weighted Method, to calculate the Combined Risk Dependency Value б, and the Combined Risk Dependency Multiplier, λ, in the case of more than one risk input.

Here $R_x = f(P_x, I_x)$, and R_x has k direct risk inputs or predecessors, $R_1, R_2, \ldots, R_k$, where $x \neq 1, \ldots, k$. The affected risk $R_x^+ = f(P_x^+, I_x)$, where $P_x^+ = P_x \lambda_x$ or $P_x^+ = P_x +$ б$_x$. The set of the Risk Dependency Values is $D_x = \{D_{1x}, D_{2x}, \ldots, D_{kx}\}$ and the set of Risk Dependency Multipliers is $DM_x = \{DM_{1x}, DM_{2x}, \ldots, DM_{kx}\}$.

The three ways for calculating the combined risk conducting effect are writing next.

148.4.1 Conservative Method

This method chooses the highest value from among all the Risk Dependency Values or all the Risk Dependency Multipliers of direct predecessors as the dependency effect on the probability of a risk or an opportunity; given the assumption that the project supply chain will put a higher priority in mitigating risks but decrease the importance in seizing opportunities. We can use this when the project is important to an organization objective, or risk will have a high impact on the project supply chain benefit, as this way will maximize the dependency effect to a risk, so there requires more resources. But for opportunities, as the method will minimize the dependency effect to an opportunity, use of this method believes that the project supply chain has limited resources on controlling opportunities, or the opportunities are not that valuable to organization benefit.

$$\varrho_x = Min(D_{1x}, D_{2x}, \ldots, D_{kx}) \tag{148.8}$$

$$\lambda_x = Min(DM_{1x}, DM_{2x}, \ldots, DM_{kx}) \tag{148.9}$$

148.4.2 Optimistic Method

This method chooses the smallest value among all the Risk Dependency Values or all the Risk Dependency Multipliers of input risks, and minimizes the dependency effect to a risk or maximizes the dependency effect to an opportunity. Comparing with the Conservative approach, for risks, it believes that the project supply chain should be less important with fewer resources, and the risk should have a small impact on the project benefit; for opportunities, it believes that the project supply chain allows more resources on controlling opportunities, or the opportunities will bring big benefit to the organization.

$$\varrho_x = Min(D_{1x}, D_{2x}, \ldots, D_{kx}) \tag{148.10}$$

$$\lambda_x = Min(DM_{1x}, DM_{2x}, \ldots, DM_{kx}) \tag{148.11}$$

148.4.3 Weighted Method

The Weighted Method gives a weighted value to each of the dependencies as to compute the combined dependency effect. As the weighting can be practiced under expert judgment or past knowledge, comparing with the Conservative and Optimistic methods, this one will be more specific in getting the combined effect. Although this method will be practiced to a number of cases, it will need project supply chain to put more efforts to analyze each of the dependencies and determine the proper weighted values. In this situation, project supply chain knowledge on managing dependencies is important.

Here risk dependency values D_{1x}, $D_{2x}, \ldots, D_{kx}$, we put each D_{ix} corresponding weighted value w_i, where $w_1 + w_2 + \cdots + w_k = 1$. The weighted Risk Dependency Value is calculated as:

$$\varrho_x = w_1 D_{1x} + w_2 D_{2x} + \cdots + w_k D_{kx} \tag{148.12}$$

In the same way, for Risk Dependency Multipliers, we have DM_{ix}, we assign DM_{ix} with corresponding weighted value w_i, and $w_1 + w_2 + \cdots + w_k = 1$. The weighted Risk dependency Multiplier is:

$$\lambda_x = w_1 DM_{1x} + w_2 DM_{2x} + \cdots + w_k DM_{kx} \tag{148.13}$$

148.5 Dependency Favorability

As the effect of risk dependency can either increase or reduce the likelihood of those affected risks, here we analyze the favorability of the dependency effect for a risk; we need to decide if the dependency effect is positive or negative.

Here is a set of known risks of a project supply chain of a period, $R(t) = \{R_1, R_2, \ldots, R_n\}$, $R_x = f(P_x, I_x)$ and $R_x \in R(t)$, and the dependency effect makes R_x to R_x^+.

(1) $R_x^+ > R_x$, the dependency effect is a negative effect
(2) $R_x^+ < R_x$, the dependency effect is a positive effect.

The difference of R_x^+ *and* R_x, for example $| R_x^+ - R_x |$ named Degree of Dependency Effect (Kwan and Leung 2009).

For risks ($I_x > 0$), a negative effect will make the risk probability increase and a positive effect will make the likelihood decrease. In the other hand, for opportunities ($I_x < 0$), a negative effect will decrease the likelihood of an opportunity and a positive effect will increase the likelihood. The degree of dependency effect of a risk makes us understand the risk level of the dependency effect.

148.6 Conclusion

Dependencies between nodes or project stages are widespread in project supply chain and are great important to their successful operation. Dependencies mainly paint a picture of business flow within a project supply chain and exert at least some influence on the overall success and quality of the project supply chain.

In this paper, we study the risk conducting effect in project supply chain by using a series of risk metrics. As the risk conducting effect can either increase or lower the probabilities of those affected risk factors, knowing the favorability is becoming important to management decision. Furthermore, after the analysis of the risk conducting effect, the relevant risk dependency response methods need to propose in the future study.

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Chapter 149
Research of Network Expansion Model of Logistics Enterprise Based on Chain Operation

Rui-yu Pan, Wei Wang and Qing Wan

Abstract At present, the dispersion of logistics resources and the lack of effective cooperation in organization are two main problems about development of the logistics industry in our country. These result in the huge waste in logistics activities and the low of logistics service ability. This paper demonstrates that the logistics enterprise chain management and innovation would be an important way to improve competitiveness of logistics enterprises and integrate Idle logistics resources in our country. This paper indicates three models of network expansion of logistics enterprise based on chain operation: regular chain; franchise chain and voluntary chain. And according to the characteristics of three chain operation modes, this paper suggests the different levels of logistics enterprise to use different chain operation mode.

Keywords Logistics enterprise · Logistics enterprise · Network expansion

149.1 Background

In the recent 20 years, the continued rapid growth has been realized in Chinese logistics industry. The total amount of the national social logistics raised from 3 trillion in 1991 to 125.4 trillion in 2010. Growth 40 times, with an average annual growth rate of 21.7 %. But, total social logistics cost per GDP reduced from 24.0 % in 1991 to 17.8 % in 2010, with an average annual reduced rate was only 1.56 %. Total social logistics cost per GDP is an important index to judge the logistics operation efficiency and modernization degree in a country. High level of total social logistics cost per GDP indicated that the development of the logistics

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industry in China only reflected in the volume growth, but the whole society logistics operation efficiency was still low. The dispersion of logistics resources and the lack of effective cooperation in organization were two main problems about development of the logistics industry in our country. These resulted in the huge waste in logistics activities and the low of logistics service ability (Zang and Hui 2010).

From the point of view of socialization division of labor, the development of the logistics industry could produce the expected benefits only based on scale operation. But logistics enterprise constructions cannot expand unlimitedly because of the limit of the logistics demand and management ability, and the division of professional also limits logistics enterprise integration expansion. On the other hand, network organization with double characteristics and advantages can give consideration to the market and enterprise. So it has both economies of scale and can avoid the "big enterprise disease" (Yan and Dong 2009). Therefore, the research and innovation of the logistics network would be an important way to improve competitiveness of logistics enterprises and integrate Idle logistics resources in our country (Ju and Xu 2007).

Now, the related research about logistics network mainly concentrated in the logistics network planning in manufacturing enterprise, large circulation enterprise and its service agencies to resolve the problem about the location of network facilities, the service distribution and routing arrangement (Lin et al. 2003; Notteboom and Winkelmans 2001). But related research about logistics network is seldom standing in the point of view of the logistics enterprise. The existing focuses on the optimization homework, logistics functions or link logistics facilities, such as the research of distribution system, inventory system, information system (Chunguang-Yi 2008), in stead of the mode of logistics enterprise network expansion and ways of operating. Therefore, this paper tries to discuss the logistics enterprise network operation problem, and organizing logistics enterprise network taking example by the experience of chain operation concept standing in the point of view of the logistics enterprise.

149.2 The Expansion Mode of Logistics Enterprise Network Based on Chain Operation

Chain management that an associated unit is made up of several branches under the unified leadership of the headquarters to take part in business activities is a kind of modern management and organization form. It stressed professional specialization under the overall planning and centralized management based on the work division to get the scale benefits. There are three types of chain operation, regular chain, franchise chain and voluntary Chain, respectively. These three forms always keep a vigorous vitality and exist widely in retail, catering industry and many services from production to today. Retail chain, franchise chain and voluntary chain. Although at present, successful cases that chain operation applies to logistics industry is rarely, it provides a innovation mode to the network expansion of logistics enterprise.

149.2.1 Regular Chain

A organization form of enterprise that the same capital owner has its assets and direct management shops to manage similar goods and services. By direct investment to set up shop whose assets belong to investors, they make unified accounting and management. The store has no independent assets and legal status and is operated by centralized and unified management from the company's headquarters.

What is regular chain is logistics enterprise establish its chain enterprise in a new location to help itself to expand business. There two ways to increase their regular chain logistics network one is direct whole investment by themselves, the other is the form of merger and holding.

Logistics enterprises generally try to establish a "standard company", and simplify and regulate it roundly from location selection, system constituting, personnel management, business operation and management. And then copy branches according to "standard shop".

The company headquarters operate, invest and manage directly. Headquarters take depth and breadth management way to control all subsidiary directly, and all subsidiary accept orders forthwith with cooperation each other. Outlets accept mutual cooperation headquarters. It emphasizes the overall planning of professional division of work on, in the division of labor based on the implementation of the centralized management, in order to get the scale benefits. It stressed professional specialization under the overall planning and centralized management based on the work division to get the scale benefits.

Its business operation model is headquarters centralized type for logistics operation. It adopts vertical management, that is, in the logistics network, there is only a command center, and all else is operating point.

149.2.2 Franchise Chain

Franchise chain is a modern organization form. The franchisor confer the franchisee for regulated period and area trade rights and use rights of exclusive goods, services and business system (including trademark, trade name, the use of the business enterprise symbol, technology, business premises and regional) according to contracts. The franchisee according to the stipulations of the contract perform business activities in unity business mode set up by franchisor and should pay the corresponding cost to franchisor (Guo and Xia 2000).

The equality and mutual benefit cooperation relations between franchise chain logistics enterprise and charter logistics network authorized by itself. Logistics enterprise headquarters and its joined enterprise belong to different capital owner, namely of logistics network afforded the capital of establishment and it has their own independent property and status of legal person. Franchise chain logistics enterprise usually doesn't take compulsory measures to charter logistics in management. On one hand, it formulates the rights and obligations of the parties according to the franchise contract; on the other hand, it guides business behavior of franchise store through the effective service, guidance and supervision.

Joined enterprises perform business activities based on contract, and should be ready to accept inspection and supervision by headquarters a, violate compasses to accept any time. If illegal should accept punishment.

149.2.3 Voluntary Chain

Voluntary chain is the formation of network organization which is combined by those enterprise with the qualifications of independent legal for the common interests. Usually, the some enterprise as a leader in this network attracts others alliance based on the principle of complement each other's advantages and resources integration and restrict the behavior of all parties and sustain economic relationship on the basis of contract.

Voluntary chain mode of logistics enterprise has the following features:

(1) The joining trader have ownership of the enterprise and independent legal status. The stores cooperate on the basis of upholding the independent legal status each other and keeping the original of the assets of the ownership. Each franchisee operates with independent accounting, admission of their own profits and losses, personnel independent arrangement, implement differentiation, and personalized management (Song 2008).

(2) Two kinds of the form of cooperating between the leading enterprise and alliance, one is cooperation based on similarity, the other is cooperation based on complementary.

    Similarity cooperation refers to leading enterprise and each store have similar logistics capability and logistics resources, to cooperate complete logistics activities through the new configuration resources. Its achievement is a formation economy of scale in a short time, share the risk and cost. Complementary cooperation is made up by partner with different core ability, completing the cooperation projects according to the principle of complementary advantages. The content of the logistics services include transportation, warehousing, distribution, packaging, customer service, information service and so on. Logistics enterprise hasn't the advantage in every detail because of its limits in resources and ability. To form complementary cooperation through joint between enterprises with different core ability and the

Table 149.1 Comparison of three types of chain management

	Appearance		
	Regular chain	Franchise chain	Voluntary chain
Ownership	Headquarters	Logistics network	Logistics network
Operation	Headquarters unified control	Business independent	Business independent
Capital	Headquarters	Joining trader	Joint venture mainly
Link	Property	Contract	Contract
Contract binding	Cooperation mainly	Independence relatively	Competitive cooperation
The branches degree of chain	All chain	All chain	Part chain

logistics demand of customer was decomposed into several parts to be assumed by independent units This separation increased the flexibility of the organization, using the combination of resources and the new way of transaction instead of emphasizing to takes the resource. So we can satisfy the logistics demand with low cost quickly and enhance the level of whole logistics.

(3) Part chain relations formed between leading enterprise and joining trader. The project cooperation is main method in Joint venture cooperation chain operation process. A project team is made up by leading enterprise and joining trader who provide capital, person, and goods together to complete a specific logistics services of customer. Because the joining trader contribute a part of resources rather than all resources in the joint venture cooperation chain mode, we think the formation of part chain relations formed between leading enterprise and joining trader in the mode of voluntary chain to distinguish retail chain and franchise chain which the joining trader contribute all the resources to join in. (Table 149.1).

149.3 The Application of Chain Operation Mode in Our Country's Logistics Enterprises

At present, the structure of the third party logistics enterprise in our country is pyramid and it is divided into three levels according to the size of the enterprise. In the first level is the some of large-scale, integrated logistics enterprise, state-owned logistics enterprise mainly, such as SINOTRANS; The second level is the rapid development third party logistics enterprise which has a certain brand awareness in the national or regional but number limited relatively, large and medium-sized private logistics enterprise mainly; The third level is many scattered, small-scale third party logistics enterprise who provide a single logistics service and compete each other in the bottom end of the logistics market.

The logistics enterprise at different levels can adopt corresponding chain operation mode according to the feature of three types of chain operation modes.

(1) Large logistics enterprise build up large enterprise groups through the retail chain.
The large logistics enterprise with strong strength who stand at the top of the pyramid can increase their retail chain logistics network through building with own capital directly or taking the form of merger or holding to construct internal network, improve the network specificity, and build a large enterprise group (Lv 2005). At the same time, it should take informational connection in the entity network through informational means. To manage integrative and achieve the scale benefits.

(2) Large and medium-sized l private logistics enterprise which rely on brand advantage build The chain system made up by joining mainly and supplemented by retail chain.
The logistics enterprise which have certain brand awareness with the increase of the stable customer pay attention to development of logistics network that has become the most basic platform for customers serviced by logistics enterprise and is key resources for development and competition of logistics enterprise. But logistics enterprise can't afford to construct network by themselves entirely because of the limit of money and time, they can expand rapidly in a short term to satisfy service needs from large customer through. The logistics enterprises expand the scale by the help of the capital from joining trader in the mode of franchise chain but it can't control joining trader effectively. So it is more suitable for regional cooperation instead of national network with big risk. In actual use, logistics enterprise should find out the key, core customers who are consistent with their own long-term planning and conjunct their development goals with these customers' logistics requirements to distribute logistics network selectively. They can consider to set up several regular chain store in the important city as logistics nodes to strengthen the control of the customer resources and reduce dependence on the joining trader. And then they can develop franchisee store around the regular chain store and build a close network system eventually.

(3) Those small and medium-sized logistics enterprise who don't want to lose "independence" established voluntary chain system.
According to report from Chinese storage association fifth Chinese logistics supply and demand market, enterprises more than 500 employees accounted for only 11 % and most of the enterprise on a smaller scale. They take scattered and extensive management and lack intensive and network management advantages include in uncompetitive. In the fierce competition, small and medium-sized logistics enterprise can choose to be merger by large logistics enterprise or become franchise chain as a concessionary chain logistics enterprise. But the former will lead to small and medium-sized logistics enterprise lose ownership

and management power and the latter will lose their reputation and the opportunity to create brand. Those small and medium-sized logistics enterprise who don't want to lose "independence" established voluntary chain system. Then, many enterprises logistics resources will be combined and will produce the effect of the large-scale economy. It will make original dispersed and competing small and medium-sized logistics enterprise survive in the fierce competitions market.

149.4 Conclusion

Network can change the logistics enterprise growth environment and network service itself is a kind of business model of logistics enterprise (Ju et al. 2009), so the network will be the path in development of logistics enterprises. Our logistics industry is at its early stages of growth. Domestic logistics enterprise usually lack perfect logistics network while foreign logistics enterprise is ongoing wide range of mergers and acquisition and large-scale transnational investment. So the scale of the logistics network is growing rapidly. The construction of domestic logistics enterprise network is imminent. But the mode that logistics enterprise develop national network by themselves completely can't become the mainstream model when they face the negative factors, such as investment size, cost, time and others. Chain operation as a modern distribution and organizational form provides a innovation strategy for network expansion of logistics enterprise. Because of the lack of reference experience about chain operation used in logistics enterprise network expansion, the third party logistics enterprise in the development process of chain operation should do according to its abilities and operate step by step to form mesh chain system gradually, and then they will achieve the economies of scale and improve the comprehensive competitive power.

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Chapter 150
The Operating System of Logistics Center Simulation and Optimization Research

San-yuan Zhou, Qiang Chen and Yu-qing Song

Abstract This article uses computer simulation method to A logistics center operation system in general and system studied. To a certain extent to overcome the most current research is concentrated in one or several specific operations research and the use of mathematical methods to the dynamic description is not enough, there are some reference values of the same study field.

Keywords Arena software · Discrete event systems · Logistics center · Simulation and optimization

150.1 Introduction

Logistics center in logistics activities plays an important role in the coordinating organizations, the logistics center operating system is the most concentrated expression of all kinds of physical resources in the logistics center (Zhang et al. 2008). Its business operation is directly related to the efficiency and economic benefits of the entire logistics center. The traditional mathematical modeling methods cannot solve the problem of the complex changes in the logistics center.

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Computer simulation method can be based on the actual situation of the simulation model, the statistics of the model simulation output analysis to assess the logistics system (Takizawa and Takakuwa 2000).

The most current research of the operating system is concentrated in one or several specific operations research, lack of its holistic and systematic research, most of the studies has also not very good according to the actual situation of the logistics center, the actual cause of logistics center and the research are disconnect. This article research a specific logistics center carried out a systematic study and analysis, it has some theoretical and practical significance (White and Teny 2001).

150.2 Examples Introduction and Simplifying Assumptions

150.2.1 Examples Introduction

A logistics center's business departments include: finance department, business development, warehousing and distribution department. The department of warehousing and distribution is the major operating departments. Distribution department provide distribution services to customers in the city, occasionally to other parts of the province's distribution, however the volume of business is very small, this article is not set this part of the distribution business shall be considered. Department of warehousing goods store management and inspection of goods shipped into operation. Packaged parts products stored in the storage area, part of the shipment by the distribution business, the arrival of orders subject to TRIA (0.1, 0.6, 1.5) hour distribution; Another part by the manufacturers using their own delivery, the arrival of orders subject to 10 + EXPO(38.6) minute distribution (Jane 2000). In purchase operations, generally manufacturers of vehicles direct delivery the goods to logistics center, the arrival of orders subject to TRIA (1, 2.5, 5.5) hour distribution. Only a small part need to pick-up, in order to simplify the model and accuracy, this article is not set to consider such orders (Wang and Cheng 2003).

150.2.2 Simplifying Assumptions

The model assumes that in order to reduce the workload and interference factors, and can more appropriately fit the real system. Simplified in this article are as follows:

1. An order contains several different set of operating instructions set to several different order entities arrive at the same time.
2. The distance between the set of logistics centers and distribution destination for the straight line distance.

3. Assuming that the vehicles average speed of 50 km/h, the delay cost per order is 100 Yuan.
4. Assume that employees can replace each other.
5. Facilities are generally not assumed that the operating system fails.

150.3 System Modeling

150.3.1 Arena Software Introduction

Arena simulation software research based on the early SIMAN/CINEMA simulation language and by Rockwell Company. It's a representative simulation software to support discrete event. As general-purpose visual simulation environment software, arena simulation software is used in many areas of research (Kelton 2010; http://www.rockwellautomation.com/).

150.3.2 Build the Simulation Model

Logistics center operating system activity is triggered by the orders received, so the starting point of the operating system of the logistics center is order research. The arrival of orders can be divided into the arrival of shipped orders and purchase orders arrive, so A logistics center operating system can be divided into shipping operations system and purchase operations system, top-level model in Fig. 150.1.

According to the actual situation of A logistics center operating system, this article in accordance with the hierarchical modeling ideas shipping the operating system is divided into warehouse order in, distribution scheduling, vehicle scheduling, loading and out and out confirmation. Purchase of the operating system model is divided into warehouse order in, unloading and in and in confirmation. Specific sub-module build is not explained in detail because of space limitation (Adil and Muppani 2008; Liu 1999).

150.4 Analysis of Simulation Results

After the model simulation, set to logistics center the service level performance indicators of output in the operating system statistics in Table 150.1.

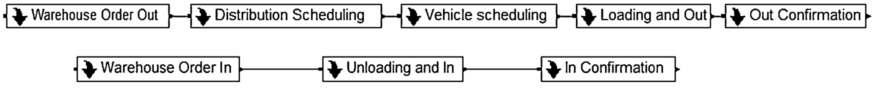
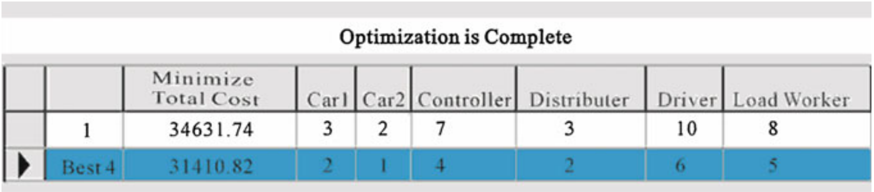


Fig. 150.1 Top-level model (Arena Training Guide 2005)

Table 150.1 Various types of service levels and output data table

Category	Name	Statistics
Space utilization	Length of site queue	2.31
	Length of out site queue	1.53
Person output	Warehouse keeper person output	0.41
	Distributor person output	0.53
Equipment operation	Number of handling equipment per day	4.70
The quality of customer service	The average daily number of orders	28.43
	Out orders delayed	0.18
	Distribution orders delayed	0.03



Optimization is Complete

		Minimize Total Cost	Car1	Car2	Controller	Distributer	Driver	Load Worker
	1	34631.74	3	2	7	3	10	8
▶	Best 4	31410.82	2	1	4	2	6	5

Fig. 150.2 Optimal allocation of resources program (Kelton 2010)

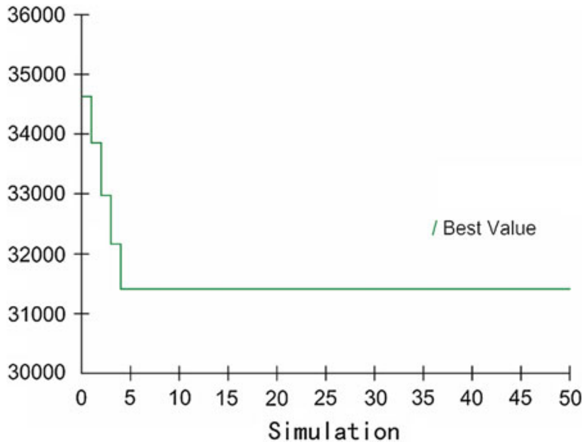


Fig. 150.3 The total cost of the *optimal curve*

It can be seen from the data in the table above, the station platform vehicles waiting in line too much, low efficiency of the warehouse keeper and the distributor. Equipment utilization is relatively low; the business is still relatively small scale, order delay deadly accuracy. These notes operating system have some problems.

Below using the OptQuest optimization package of the Arena simulation software into the operating system resources to optimize the study (Kelton et al. 2007). The objective function is to minimize the total cost of the operating system. System operators, vehicles and equipment and other resources for the control variables (Bartholdi and Hackman 2005; De Koster et al. 2007). Obtained the optimal solution of resource allocation and cost curve changes in Figs. 150.2 and 150.3 (Macro and Salmi 2002).

When the simulation optimization runs to 4th, two own vehicle, controller, distributor, driver and load worker value respectively 2, 1, 4, 2, 6, 5. The total cost function to obtain the optimal value is 31410.82 Yuan, so 3220.92 Yuan less than the optimized configuration program before, it can be seen optimize the cost has been reduced to a great extent (http://highered.mcgraw-hill.com/sites/0073376280/).

150.5 Conclusion

The article uses computer simulation of a holistic and systematic study of the operating system of the logistics center, using OptQuest optimization package comes with the arena software simulation to optimize the current allocation of resources, get the best allocation of resources. So there are some reference values to the same field.

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Chapter 151
Emergency Logistics Management of Public Sector Organizations Treating Incident

Shao-juan Feng, Meng Wang, Hai-chuan Feng, An-qi Shen and Min-yi Yang

Abstract This paper aims to analyze the characteristics and metrics of emergency logistics to public sector organizations, in order to manage emergency logistics more efficiently and effectively. Based on analyzing the characteristics of emergency logistics management for incidents and reviewing past practices, it applies integrated supply chain management theories to the performance assessment, and sets up a three tiers' index system with 39 indicators, involving reliability, agility, flexibility, and cost-effectiveness in the first tier as goals, to assess the all-round performance of emergency logistics management. Then it combines hierarchy analysis process (HAP) and fuzzy comprehensive evaluation into the performance metrics. Also, it explains the results of the reliability evaluation of emergency logistics supply chain management, taking the Wenchuan earthquake incident as an example. By this performance assessment index system, some specific problems in emergency logistics management, such as operation coordination, supply chain links, and information communication, could be found and measured.

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Keywords Emergency incident · Emergency logistics · Integrated supply chain management · Performance metrics · Public sector organization · Wenchuan earthquake

151.1 Introduction

Since 1980s, more literatures have been referred to emergency incidents. By a summary review, they are the kinds of incidents with abnormal, occurring abruptly and treating immediately (Fan 2007; Liao 2009). Moreover, some incidents could take government into crisis for the critical negative impact on people and/or society. So, governments concentrate efforts on emergency incidents. For examples, in China, emergency incidents are classified into natural disaster, accident disaster, public health incident, and society security incident; in USA, they are biology class, disaster nature, computer cyber, food and agriculture, nuclear radiation, oil and hazardous materials, and terrorist incident (Department of Homeland Security 2008). Although the emergency incident classes are varying with the different countries as their challenging with the different securities and/or threats, all of the emergency incidents are impacting on people lives, society stabilization, and country interests.

It is the varying non-traditional threats under highly changing and complex environment that governments all over the world make efforts to improve the emergency capacity. Hereinto emergency logistics is vital to support people lives as soon as the possible in the golden rescue time. Although literatures have studied many emergency logistics management issues, such as manpower mobilization, operation procedure, contingency coordination, command chain, there is little information available in literatures about performance assessment for the multi-components (Fu et al. 2008). As facts, practical problems, including delayed decisions, separated resources, choked transportation, occur not uncommon. Here, we present integrated supply chain management into emergency logistics. The purposes of this paper are analyzing the characteristics and putting forward to metrics of emergency logistics supply chain management.

151.2 Characteristics Analysis

151.2.1 Surging Requirements and Orders Immediately

Because of the incidents taking places irregularly, public sectors would get the response orders at any time and should implement in the tight hours. In such a context, it is critical factors constraining emergency logistics that if the public functional areas could response as soon as possible and the readiness deployments are in the right places. The most character of emergency logistics is the surging requirements immediately and non-forecasting. It results in very rigid time effectiveness for emergency logistics operations and management, from acquiring the necessary materials and equipments to distribution them in right time, in right items and in right places (Zang 2004). So, the contingency logistics procedure should be both reliable and simple. And a quick response system and coordinating logistics management mechanism are needed to insure a powerful logistics support.

151.2.2 More Cross-Functional Areas and Joint Commands

Because incidents are very different features and affect society extensively, it should be joint governmental, military, civil, non-profit, and volunteer forces involved in the operations. With such cross-functional organizations and different command chains, a mess and poor emergency logistics operations may be occurring. In the other words, it makes emergency logistics command and coordination more difficultly. A supply chain management concept could take an important place (Farahain et al. 2009).

151.2.3 Frequent Adjustment and Changing Deployment

As it can not be estimated exactly for when incident may occur, how long it could sustainment, where it ranges from incidences, and what intensity it could take, all of these factors make emergency logistics resource starting and items acquiring indefinitely. Additional, even in the sustainment operations, the support activities are varying with the incident dealing conditions. So, a varying logistics would result from a frequent adjustment and changing deployment. Moreover, a short lead time by the contingency materials demands is coming here and there. Then, emergency logistics management should improve the support timeliness and supply chain flexibility.

With the worsening environment, more and more governments have been concentrating on improving emergency logistics management. For examples, the American has set up a robust emergency logistics management system to get a well joint commands and coordination; the Japanese values on definite emergency logistics operation stages to improve deployment (Li and Wang 2010); the German takes advantages of civil organization into emergency logistics operation to adapt the changing demands; and the Chinese pay more attention to construct an integrated military-civilian emergency logistics system. Taking the Wenchuan Earthquake in China on May 2008 as an example, the emergency logistics management of the public sector organizations is performed with the followings:

- *Organizing and commanding of emergency logistic*. As hearing from the earthquake incident, the Chinese government started *the Overall Emergency Response Plan for the National Public Emergency Incident* immediately and established the headquarters of national earthquake rescue. Relevant functional department did the tasks of logistics support, such as capacity support, traffic control, reserve utilized, distribution handling and emergency delivery.
- *Procurement of emergency items*. There are many ways of emergency goods and service procurement, for example, using of the usual reserve, compulsory acquisition directly, the market emergency procurement, organizing the assault development and production, organizing the donations in society, and receiving international assistance. Through the ways above, government raised large quantities of materials in earthquake rescue.
- *Warehousing of emergency items*. The Ministry of Civil Affairs issues thousands of tents from central stock points as soon as possible, the national stock management agency mobilizes strategic stock foods, the Army supports first-aid medicines, and local medicine agents present epidemic prevent medicines.
- *Distribution of emergency items*. In 2 h of the earthquake, kinds of government sectors and the Army forces start emergency support plan. The distribution solutions are included in controlling the access roads entry to Sichuan, and channeling a multimode transportation system for emergency materials. But communication system is not good enough that makes the emergency demand information is delayed.

As stated above, public sector organizations are involved in emergency logistics supply chains by their different ways. Anyway, the emergency logistics management of public sector organizations treating incident, dealing with cross-functional areas, is a complex systems engineering (Han 2004). Meanwhile, practical problems, including delayed decisions, separated sources, choked transportation, occur not uncommon. So, performance assessment of emergency logistics supply chain management is needed to facilitate an efficient and effective public sector organization system getting more powerful capability for the kinds of incidents.

151.3 Performance metrics

151.3.1 Performance Index System

Emergency logistics supply chain management is a complex and systematic project with multi-components, high timeliness and effective coordination. It is required for a better reliable, flexible and agile performance. Meanwhile, costs effectiveness should be taken into account as well. Based on literature reviews and questionnaire (Bai 2007; Fu and Chen 2009; Wu 2005; Xu and Wang 2009; Li et al. 2007; Ma 2009; Zhou 2009), we get the following performance index system that takes care of about 39 different indicators, as shown in Table 151.1.

Table 151.1 Performance index system

Goals	Objectives	Indicators	Contents
Reliability	Reliable sourcing	Reliable pipeline	Contingency and sustainment procurement capability, materials stock and mobilization capability
		Right materials	Right quantity, variety, and specification
	Reliable organizing	Efficient command	Establishing an integrated organization system, good support relationship, and clearable responsibility
		Qualified personnel	Whether the personnel qualifies the know-how on contingency re-source acquiring, shipping and receiving, and distribution
		Adequate facilities	Whether the activities, facilities, and equipments are satisfied by the requirement of task, expressed as fill rate
		Cooperating operation	Integrated military-civil system, joint links
	Reliable transport and distribution	Transport availability	Transportation coordination mechanism, involving both civil-military and public- private sector, including airway, railway, highway, and waterway
		Rational transport layout	Whether transportation network is available to multi-mode transport
		Conveyance arrangement	Efficiency of multimode transport, Level of integrated transport
		Vehicle routing	Whether the vehicle routing is unimpeded
		Robust emergency distribution network	Throughput in distribution center, distribution operation process, adequate distribution facility
	Reliable information system	Information acquiring capability	Measuring the quantity and sourcing channel of information.
		Information transmission capability	Measuring the transmission speed of information
		Information sharing capability	Measuring the scope and quantity of sharing information.
		Information processing capability	Measuring to the speed and quantity of information processing

(continued)

Table 151.1 (continued)

Goals	Objectives	Indicators	Contents
Agility	Response agility	Sense speed	Mean time from incident occurring to the moment emergency logistics agency recognizing the requirement
		Response speed	The time from the moment through receiving customers' requirement to developing emergency plan.
	Support agility	Contingency procurement lead time	The time from order fulfillment to supplier delivered to the assigned places
		Contingency shipping and receiving time	The time cost by loading and un-loading of storage, transiting, stowing
		Transportation operation time	The total transport time from loading to unloading, including transfer time and stop-off time
		Distribution operation time	The mean time from the requirement application to receiving materials
		Green channel mechanism	Simplified procedure and endowed the emergency material priority
Flexibility	Flexible process	Flexible planning	Alternative of emergency plans, Adjustability of plans
		Flexible acquiring	Quantity, quality and approaches of acquisition
		Flexible inventory	The breadth and the in-depth storage
		Flexible distribution	Capability of changing distribution time, place and quantity
	Flexible organizing	Flexible organizing structure	Capacity of organizational modularity and cross-function
		Flexible organizing management	Cooperation of phases and department.
		Flexible organizational culture	Organizational culture compatibility
		Flexible human resource	Learning competence and innovating capability of workforces
	Organizing resource	Flexible supplier relationship	Transferring time, cost, and scope with supplier relationship
		Flexible facility	Currency and restoration level of establishment and facility
		Flexible mobilization capacity	Mobilization capacity of material, transport and human resource

(continued)

Table 151.1 (continued)

Goals	Objectives	Indicators	Contents
Cost-Effective-ness	Procurement cost-effectiveness	Purchasing fund efficiency	Purchasing entities makes more with less money in the specific time
	Stock cost-effectiveness	Warehouse resource efficiency	Utilization ratio of land, ware-house area and capacity, and facility
		Capability of storage	Warehouse stability, inventory cost, inventory turnover rate
	Transport cost-effectiveness	Conveyance capability	Utilization ratio of loading and transport distance, productivity of transport
		Transport unit cost	Total transport costs/total freight turnover
		Military and social effectiveness	Military and social effectiveness during transport operation

151.3.2 Evaluation Technique

Performance assessment of emergency logistics management for incidents is a complex problem. Also is the evaluation index system involving tangible and intangible factors and multi-tiers, and the uncertainties of many critical factors. Therefore, this paper integrated Analytic Hierarchy Process (AHP) and Fuzzy Comprehensive Evaluation to consider both qualitative and quantitative factors in evaluating the performance of emergency logistics management.

151.3.3 Experimental Illustration

Step 1: Using the analytic hierarchy process (AHP) and combining with the reliability of individual indicators in the emergency logistics management evaluation index system, the reliability hierarchical model could be established (in Fig. 151.1). Also the weights of each index should be calculated.

$$W_A = (0.3, 0.2, 0.3, 0.2)$$
$$W_B = (0.6, 0.4)$$

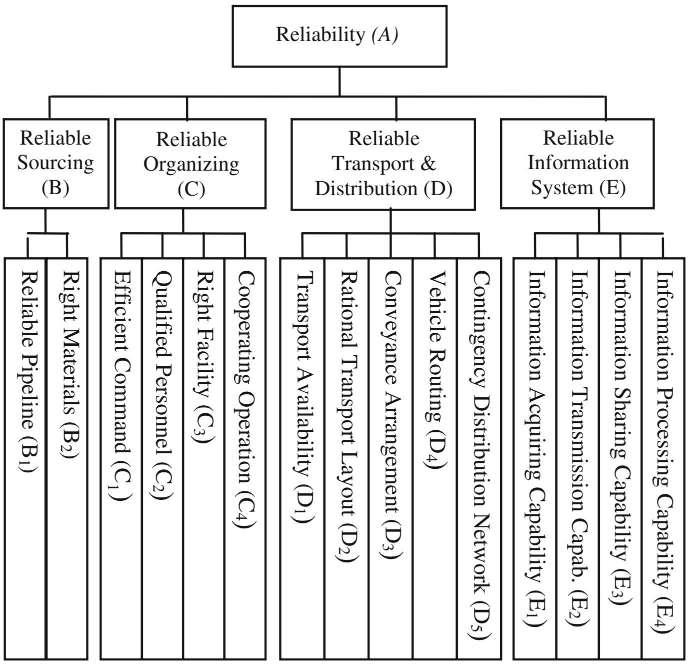

Fig. 151.1 Structure model of reliability of evaluation level

$$W_C = (0.3, 0.2, 0.3, 0.2)$$
$$W_D = (0.1, 0.2, 0.1, 0.3, 0.3)$$
$$W_E = (0.2, 0.3, 0.2, 0.3)$$

Step 2: 10 experts are chosen to score each measure indicator with the specific situation of emergency logistics reliability in Wenchuan rescuing, from 9 to 1.

$$V = (V_1, V_2, V_3, V_4, V_5) = (9, 7, 5, 3, 1)$$

Collecting the scores, we can get the evaluation of weighting coefficient matrix, shown in Table 151.2.

Step 3: Calculating the fuzzy evaluation in the minimum layer.

To the reliability B of source of materials, the weight of the fuzzy subset and the fuzzy evaluation matrix are shown as follow:

$$W_B = (0.6, 0.4); R_B = \begin{bmatrix} 0.3 & 0.3 & 0.2 & 0.2 & 0 \\ 0.5 & 0.3 & 0.1 & 0.1 & 0 \end{bmatrix}$$

And the corresponding fuzzy comprehensive evaluation set is:

$$U_B = W_B * R_B = (0.38, 0.3, 0.16, 0.16, 0)$$

In the same way, the corresponding fuzzy comprehensive evaluation sets for the reliability of organizational strength, transport distribution and information system are exhibited respectively:

Table 151.2 Expert evaluation

Goals and weights		Objectives and weights		Scores distribution				
Goals	Wei.	Obj.	Wei.	9	7	5	3	1
Reliable sourcing (B)	0.3	B_1	0.6	3	3	2	2	0
		B_2	0.4	5	3	1	1	0
Reliable organizing (C)	0.2	C_1	0.3	4	4	1	1	0
		C_2	0.2	5	2	1	1	1
		C_3	0.3	3	3	2	2	1
		C_4	0.2	3	4	2	1	0
Reliable transport and distribution (D)	0.3	D_1	0.1	4	3	2	0	1
		D_2	0.2	4	3	3	0	0
		D_3	0.1	5	4	1	0	0
		D_4	0.3	0	0	2	4	4
		D_5	0.3	3	5	1	1	0
Reliable information system (E)	0.2	E_1	0.2	3	4	2	1	0
		E_2	0.3	4	4	2	0	0
		E_3	0.2	3	3	4	0	0
		E_4	0.3	2	5	2	0	1

$$U_C = W_C * R_C = (0.37, 0.33, 0.15, 0.13, 0.05)$$
$$U_D = W_D * R_D = (0.26, 0.28, 0.18, 0.15, 0.13)$$
$$U_E = W_E * R_E = (0.3, 0.41, 0.24, 0.02, 0.03)$$

Step 4: Calculating the value of the target layer.

To the reliability (A) in the target layer, the weight is:

$$W_A = (0.3, 0.2, 0.3, 0.2)$$

So, the reliability of the fuzzy comprehensive evaluation set in the target layer is:

$$\begin{aligned} U = W_{\mathrm{A}} * R &= (0.3, 0.2, 0.3, 0.2)\begin{pmatrix} 0.38 & 0.3 & 0.16 & 0.16 & 0 \\ 0.37 & 0.33 & 0.15 & 0.13 & 0.05 \\ 0.26 & 0.28 & 0.18 & 0.15 & 0.13 \\ 0.3 & 0.41 & 0.24 & 0.02 & 0.03 \end{pmatrix} \\ &= (0.326, 0.322, 0.18, 0.123, 0.055) \end{aligned}$$

The comprehensive evaluation value of the evaluation target is: $G = U{*}V^T = 6.512$.

Through the methods stated above, we can find out the evaluation of disposing the other aspects in incident of emergency logistics management performance index and find out the overall performance level of emergency logistics management in the practical work.

151.4 Conclusion

The result shows that 32.6 % of the experts argue that the performance of emergency logistics management treating the incident is Very Successful, 32.2 % is Successful, 18 % is Fairly Successful, 12.3 % is Marginally Successful, and 5.5 % is Not Successful. In addition, reliability of sourcing, organizing strength, and information system have a better mean score, as about 70 % of the experts approves that they are very successful or successful. While reliability of transport distribution should be strengthen because nearly 30 % thinks it marginally successful or not successful. The results are able to assist decision-makers to examine the strengths and weaknesses to further promote the ability to treat incident.

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Chapter 152
Construction of the Supplier Evaluation Index System Based on Supply Chain

Hui-shan Li, Chun-xian Wang and Chun-he Zhang

Abstract In order to make the supply chain select the best suppliers, the supplier system is defined and analyzed, finding out the main influencing factors. An index of estimation system is established, and synthesis estimation system for it has been built. In addition, it includes 4 principal indexes, 17 s grade indexes which can reflect the comprehensive abilities. By using the AHP method, defines the proportion of every factor, each index can be transformed into a standardized mark. 11 suppliers are selected, the index weights and then the linear weighted sum method is used to calculated the comprehensive ability score and by comparing these scores, which realizes the aim of quantitative analysis.

Keywords Evaluation method · Index system · Supply chain · Supplier

152.1 Introduction

Supply chain has connected together the customer and supplier together such as the chain, and the connection and related tasks is assumed by means of purchasing department. Suppliers have an important impact on supply chain performance. Efficient logistics providers can help enterprises obtain highly efficient supply chain systems. How to select suppliers in many of the long-term strategic partner, become purchasing management department relevant issues to resolve. It is more to supplier evaluation index system and the standard (Tsaur 2010; Tseng 2010), but so in some ways it is not fitting in very well on certain feasibility evaluation

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index system and standard, following the supply chain concept into the supplier evaluation process (Uwizeye and Raymond 2009; Wei et al. 2005; Xiao et al. 2005). It is the lack of systematic and comprehensive. These research results are mainly based on a single materials supply process and a single vendor selection process (Dickson 1996). They cannot fully reflect the breadth of a supplies process in the supply chain system. Supplier evaluation system and standard are the foundation of the relationship supply chain operation, how to reflect the authentic representation has certain practical significance.

152.2 Comprehensive Evaluation Index System Established

The evaluation criteria of supplier selection began in the Dickson study of 1996. Dickson agreed that product quality, cost, and delivery time are the most important criteria of supplier selection (Yun 2001; Weber Charles et al. 1991; Yang et al. 2006). And others studies, supplier selection should be based on actual needs, make meticulous investigation and analysis, fully aware of the supplier situation and overall balance, and select a few alternative suppliers. Then make a quantitative analysis of the comprehensive capacity of these suppliers to select the best (Liu 2005; Belgacem and Hifi 2008; Sun and Peng 2004). Under the supply chain environment suppliers was gave a very thorough comprehensive evaluation, must having a complete and scientific comprehensive evaluation index system. General supplier evaluation focuses on some short-term, such as price, quality, delivery and the historical performance other procurement related indicators (Karpak and Kasuganti 2001; Youngpil and M young 2003). Based on supply chain purchase, the strategic, sustainability, complementary and compatibility other aspects of the content should be paid more attention too.

152.2.1 Supplier Evaluation Factors

The system is made up of suppliers, procurement department and users to complete the activities. The supplier should meet the requirements, Mainly involves the supplier product competitiveness and suppliers the internal environment of the supplier and living environment and suppliers ability of cooperation aspects etc. (Yang et al. 2001) Supplier's products competitiveness is mainly embodied in the prices of the products, the cost of the products, the quality of the products, delivery of the products, the service and flexible for the products. The supplier internal environment is mainly embodied in the product production capacity, business operations, technical skills, management system. Supplier's living environment is exactly a supplier facing the survival and development of the environment, reflected in the political and legal environment, the social culture environment, the economy and technology environment, the natural geographical environment. Supplier's ability of cooperation is mainly embodied in the ability of cooperation between technical compatibility, information platform compatibility, enterprise culture compatibility and credibility.

152.2.2 Comprehensive Evaluation Index System

The complexity of the supplier evaluation is considered, with the analysis of influence factors to establish a set of mutual connection and complement and interdependent principal index (shown in Table 152.1). The elements of the hierarchy can relate to any aspect of the decision problem. Based on this, according to the results of the analysis system, Second principal index related to principal index is set. One should explain it, while selecting supplies, supply chains generally lay stress on these factors: quality, price and delivery time. The quality and delivery punctuality should be required first. Therefore, this paper selects the evaluation indices associated with quality and delivery punctuality. The indices are shown in Table 152.1. The quality factors include the products qualified degree, industry standard products, production environment, the production process quality control, as well as the quality system and quality standards. Among them, the supplier product quality is reliable, that is a very important evaluation index. Suppliers must have a good quality control system, provide products must be able to continue to achieve stable product manual request. Service factors generally lay stress on these factors: the service attitude, the service response speed, dealing with complaints ability, product technical support and after-sales service. The service quality and after-sales are very important index, as a result of selecting suppliers to carefully consider the factors. The delivery time is the most important factor generally lays stress on these factors: suppliers' production cycle, production plan planning and flexibility, the inventory preparation, the order response speed, the transportation conditions and ability etc. The technical ability includes research and development of new products, the project management capability and the quality of the staff, etc. Each node in the supply chain, attention was held on the supplier research and development ability and financial condition. But in the evaluation of suppliers, the technical ability is to balance the factors considered. Supplier prestige includes contract performance ability and the supplier's financial condition credit standing.

152.3 Comprehensive Evaluation Method

The key problems that constitute comprehensive evaluation index system is the selection of evaluation methods. At present, in the practice of the widely used in

Table 152.1 Supplier comprehensive evaluation index system

Principal index	Second Principal index	Weight	Relation matrix (index status)			
			Very high	High	Common	Low
Supplier's products competitiveness (0.312)	Cost	0.244	3	4	3	0
	Quality	0.213	1	2	5	2
	Delivery time	0.243	2	1	5	2
	Service	0.184	1	1	6	2
	Flexible	0.116	0	2	5	3
Supplier's internal environment (0.225)	Production capacity	0.267	1	3	4	1
	Technical skills	0.298	1	3	5	1
	Business operations	0.253	2	3	5	0
	Management system	0.182	0	2	5	3
Supplier's living environment (0.249)	Economy environment	0.242	4	3	3	0
	Geographical environment	0.281	2	3	4	1
	Social culture environment	0.239	1	3	4	2
	Legal environment	0.238	1	3	4	2
Supplier's ability of cooperation (0.214)	Technical compatibility	0.325	1	3	5	1
	Information compatibility	0.175	1	3	4	2
	Culture compatibility	0.257	1	4	4	1
	Credibility	0.243	2	2	5	1

evaluation method, such as weighted summation evaluation and square root evaluation method are too simple, but difficult to meet the needs of the comprehensive evaluation. The differences of the indices dimensions and magnitudes affect the evaluation results and result in poor decisions. So we should perform standardized processing of evaluation to transform them into standard mark which has dimensionless and the same magnitude. According to the supply chain construction assessment of the characteristics and requirement, we used the analytic hierarchy process (AHP) comprehensive, and confirm index weight (Yang and Kuo 2003). The index weight reflects the importance of the index. The determination of the weights must reflect system functional requirements. This paper uses the expert method to determine the index weight.

152.3.1 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a structured technique for helping people deal with complex decisions (Wei et al. 2005). The AHP provides a comprehensive and rational framework for structuring a problem, for representing and quantifying its elements. Once the hierarchy is built, the decision makers systematically evaluate its various elements, comparing them to one another in pairs. It is to measure the index of the scale of the relative importance, a indicators of the index system to all other index effects. The judgment matrix is constructed. The matrix is shown in formulate (152.1).

A criterion compared with itself is always assigned the value 1 so the main diagonal entries of the comparison matrix are all 1. The numbers 3, 5, 7, and 9 correspond to the verbal judgments "moderately more dominant", "strongly more dominant", "very strongly more dominant", and "extremely more dominant" (with 2, 4, 6, and 8 for compromise between the previous values). Reciprocal values are automatically entered in the transpose position. One is allowed to interpolate values between the integers, if desired.

$$A = \begin{vmatrix} a_{11} & a_{12} & \cdots & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & a_{n3} & \cdots & a_{nn} \end{vmatrix} \quad (152.1)$$

152.3.2 Calculation Under a Criterion of the Relative Weight

The weights for the defined criteria are developed on the basis of the well-known numerical scale for preference values ranging from 1 to 9. The criteria weights have the strongest impact on the results and hence the determination of their preference values is often the subject of debate among the interest groups involved. To avoid these debates, one should allow each interest group to establish its own matrix of preference values.

For quantitative indices, we adopt vector normalization to perform standardized processing. By the optimization method, the comprehensive weight can be calculated, and consistency examined. In a judgment matrix A, characteristic root can be calculated, by $AW = \lambda_{\max} W$. All regularized W belong to the same scale as the weights. Generally the approximate method can be used to solution $\lambda_{\max}$ and W.

(1) Calculation the judgment matrix line vectors product M_i:

$$M_i = \prod_{j=1}^{n} a_{i,j} (i = 1, 2, \ldots n) \quad (152.2)$$

(2) The calculate formulas of nth roots of M_i:

$$p_i = \sqrt[n]{M_i} \quad (152.3)$$

(3) P_i normalized, get the weight of each index, It is denoted as:

$$w_i = {}^{p_i}\Big/{\sum p_i}\ (i = 1, 2\ldots n) \tag{152.4}$$

(4) Judgment principal matrix with satisfied consistency. The biggest characteristic of the consistency condition is equal the judgment matrix of root and matrix order number, so consistency evaluation value of treatment for customs is as follows:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad \text{where, } \lambda_{\max} = \sum_{i=1}^{n} \frac{(AW)_I}{n\, w_i}$$

$(AW)_I$ mean the I-th elements of *A*

$$CR = CI/RI \tag{152.5}$$

Note that the consistency ratios CR for the derived weights are above 0.1 which would require a revision of the preference matrix. However, the threshold value of 0.1 for the consistency ratio is derived from expert judgment and experience and should therefore not be a formal constraint. Moreover, a *CR* of about 0.12 is only slightly above the recommended value of 0.1 and the derived weights from tables I plausibly reflect the assigned preference values. Therefore, the preference matrices were not revised and were used to derive the weights for the subsequent weighted criteria summation.

152.4 Discussion

Measure supplier evaluation standard is the objective measure, supplier to the level of comprehensive ability, with the standard to measure, is clear at a glance. The dimension of supplier indexes on supply chain is different, for example cost and technology ability indexes are different units or content. In order to eliminate the influence of dimensional, must through the mathematical transformation of every evaluation index dimensionless processing, that is to say, actual value of the indexes will be the respectively into may same with the measure index score. Only in this way, it will be possible to put more different dimensional evaluation index integrated into a value. For quantitative indices, we adopt supplier normalization to perform standardized processing, the formula of supplier normalization is shown in formulate (152.6).

where the *i*th item index scores-d_i; the *i*th item measured value- x_i; the *i*th item don't allow the value- $x_i^{(s)}$; the *i*th item maximum value-$x_i^{(h)}$.

$$d_i = \frac{x_i - x_i^{(s)}}{x_i^{(h)} - x_i^{(s)}} \tag{152.6}$$

Table 152.2 The 11 suppliers evaluation index treatment data

Supplier	X_1	X_2	X_3	X_4
N_1	0.75	0.92	0.56	0.71
N_2	0.83	0.93	0.61	0.87
N_3	0.72	0.72	0.70	0.63
N_4	0.95	0.89	0.68	0.85
N_5	0.75	0.84	0.71	0.79
N_6	0.85	0.86	0.36	0.88
N_7	0.95	0.87	0.4	0.95
N_8	0.96	0.94	0.72	0.98
N_9	0.71	0.56	0.32	0.27
N_{10}	0.68	0.67	0.36	0.82
N_{11}	0.61	0.59	0.28	0.51

Usually, the measured value for each index in between not allow value and the most satisfaction value, is replaced by $x_i^{(s)} < x_i < x_i^{(h)}$, then $60\,mark < d_i < 100$ mark. Under special conditions, let $x_i = x_i^{(s)}, d_i = 60$ mark (just right pass); then $x_i = x_i^{(h)}$, $d_i = 100$ mark (maximum value). Whether positive or negative index, all can be calculated by using the formula of the supplier points, the index score for the index is "satisfaction rating", may with the measure. For example, evaluation criteria are divided into excellent, good, fair, poor four ranks, same as A, B, C, D. Supplier's products competitiveness in principal index, the delivery time, in a period of time the ratio of delivery times on time N_t and the number of the total delivery frequency N is greater than 95 %, to determine the grade A. If it reached 60 %, based on the formula that the 60 %/95 % = 63 % (to the grade A level about 60 %) reach the grade B (including 60–90 %). Where, 40 %/60 % = 67 % (to the grade B only 60 %) reach the grade C (including 40–60 %). So, 25 %/40 % = 63 % (to the grade C only 60 %) reach the grade D (including 25–40 %). So on it can be got the secondary indexes of the specific A, B, C, D standards.

152.5 Conclusion

With 11 suppliers $N_1, N_2, \ldots, N_{11}$, purchasing management departments use the evaluation index system for the 11 suppliers on the evaluation. First, through the questionnaire survey and data acquisition get second principal index weight, aggregative them get principal index, standardized treatment data is shown Table 152.2. See Table 152.2 for the analysis of relative weightings in valid survey responses. In the first tier evaluation aspects, the rankings of factors among the 11 suppliers are: (1) Supplier's products competitiveness N_8 (0.96); (2) Supplier's internal environment N_8 (0.94);(3) Supplier's internal environment N_8 (0.72);(4) Supplier's ability of cooperation (0.98). We proposed a comprehensive model to select the best supplier N_8. AHP enabled us to incorporate 17 factors that are both qualitative and quantitative for assessing the vendors. Although the final decision indicates that N_8 dominates the other suppliers rather decisively based on these many factors, in the end the managers decided to allocate the order quantities between the two top suppliers in the supply chain, most likely to have some redundancy. It shows us that the number of criteria included in the supplier selection process is quite important. Although we initially considered 17 criteria, we went through an initial trimming process and eliminated four of them. The choice and number of factors to be included in the supplier selection process must be conservatively selected since the decision-making process is complex. Because of the complexity of decision making, fuzzy thinking of human judgment, a hybrid comparison matrix is not completely consistent in some situations. Some deviations should be permitted.

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Chapter 153
Supply Chain Finance Credit Risk Evaluation Based on Trapezoid Fuzzy Number

Xing Bi, Xin Dong and Yu-tong Liu

Abstract Supply chain finance has tremendous development potential as a new type of bank financing product. However, its risk is also developing gradually towards the direction of complexity. The paper has established an evaluation system for the credit risk of supply chain finance, which evaluates all the indices of the index system with the method of trapezoid fuzzy number combined with the entropy weight theory, hence increasing the accuracy of the evaluation. This combined evaluation method can surmount the deficiency of the method evaluated by triangular fuzzy numbers and other methods, and lower the errors in judgement of the credit risk in supply chain finance, so it is relatively a scientific evaluation method.

Keywords Supply chain finance · Credit risk · Trapezoid fuzzy number · Entropy weight

153.1 Introduction

In recent years, as a new bank financial product, supply chain finance has gained rapid development. This new model promotes fund integration effectively. It can not only meet the finance requirements of small- and medium-sized enterprises (SMES) in the supply chain, but also help these enterprises get loan. Supply chain finance has been promoted as more and more banks began to conduct SMES credit in a more fierce competition situation (Diercks 2004). Especially since the

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financial crisis in 2008, supply chain finance has undergone rapid development and large logistics companies and banks devote major efforts to the business to make profit. In these days, banks do business in supply chain finance in varied forms which include credit and factoring in the form of capital guarantee, L/C, and honour in the form of bank credit; and services like account management, account settlement and corporate finance (Noah and Anthony 1997; Satty 1980). After joining in the supply chain finance, banks evaluate the payment capacity and credit support of core enterprises and design for SMES the credit by the use of inventory pledge or receivables, which can also solve the problems of credit imbalances and fill the finance gap of SMES, finally realizing a three-side winning situation in which banks, enterprises and logistics companies all get profit.

For a long time, SMES credit has been taking a only small proportion in the business conducted by banks, which have not found an index system of credit-risk evaluation for SMES and have no complete SMES credit-risk evaluation system for a special finance product either. With the development of supply chain finance, credit risk incidents between banks and SMES also occur one after another endlessly, which can be classified into four categories. Firstly, enterprise breaches the contract and changes the use of capital without the permission of the bank (Hartley-Urquhart 2006). Secondly, the enterprise conceals the revenue to shirk the duty of paying back the debt, or cheat the bank with the excuse of investment failure to make the bank suffer from the loss (Lewis 2007). Thirdly, after getting the loan, enterprises sustain capital loss for the reason that they don't manage the money well or that the employees don't work hard (Bernabucci 2005). Fourthly, malicious loans of the enterprise with no intention of repaying them make the bank suffer a lot from dead loans (Xu 2004).

So, on currently existing foundation of credit risk analysis of SMES, this articles make a credit risk evaluation model of SMES in supply chain finance with the basis of Trapezoid fuzzy number.

153.2 Credit Analysis of Supply Chain Finance

Credit risk of supply chain finance mainly indicates the risk that the bank suffers when the enterprise cannot totally or partly repay the loan because of the reasons above. So evaluation and discernment of enterprise's repayment capacity is a key part of credit loan. In the operating activities of a bank, evaluating credit risk rationally can decrease credit risk effectively. In the process of evaluation, a set of rational credit evaluation system, which can get the credit information of an enterprise by tracking, analyzing and summarizing the credit indices in a certain operation period, should be established. Study on credit risk of supply chain finance has seen some achievements in China. The evaluation of using FAHP, mainly by Zhao and Li (2011), is a relatively simple evaluation method. Bai (2011) takes the method of the value of fuzzy evaluation, membership vector fuzzy evaluation, and typical fuzzy comprehensive evaluation method to do credit risk analysis of supply chain finance. Xiong et al. (2009) come up with a credit risk evaluation system which concerns main rating and debt rating, and applies PCA and Logist probit in setting up a credit risk evaluation model. From the research achievements above, it can be seen that credit risk of supply chain finance can be affected by many factors. There are a lot of risk evaluation methods, among which the frequently used ones are fuzzy comprehensive evaluation method, gray comprehensive evaluation method, GAHP and neural network evaluation method. Though these methods are simple, the evaluation effects can be influenced as they are not likely to get all the necessary information. On the other hand, supply chain finance is related to many factors. It is hard to give accurate judgments to every criterion. So the uncertainty of credit risk was not fully considered by these research achievements and methods, which cannot provide enough decision-making information for a decision maker.

The using of fuzzy number to quantify the entire evaluation index can put the information into full use. In the past, the evaluation method of Triangular Fuzzy Number was adopted (Kundu 1997; Sengupta and Pal 2000). However, it can't reflect the decision-making information effectively as Triangular Fuzzy Number belongs to a simple function. Trapezoidal fuzzy number is a better choice and has an edge in the evaluation of credit risk in supply chain finance as it doesn't have such defect and can reflect a decision-maker's subjectivity better. Considering that the comprehension or emphasis of evaluation indices is varied among experts, which leads to a different survey result, the idea of entropy weight is introduced to revise the weight of every index and make the evaluation result more rational.

153.3 A Credit Risk Evaluation Model of SMES in Supply Chain Finance with the Basis of Trapezoid Fuzzy Number

153.3.1 The Establishment of Credit Risk Evaluation System in Supply Chain Finance

The factors that affect credit risk level in supply chain finance are rather complicate and they mainly include credit risk from enterprises themselves and the supply chain. From the aspect of the enterprises, their credit risks are mainly affected by themselves. From the aspect of the supply chain, it plays an important role in affecting the credit risk level the enterprise. As a whole, industry conditions, enterprise's conditions, core enterprises' conditions and supply conditions should be considered when analyzing the factors that affect credit risk of enterprises in a supply chain. As a result, according to the four conditions above, the evaluation index system is established as follows (Fig. 153.1).

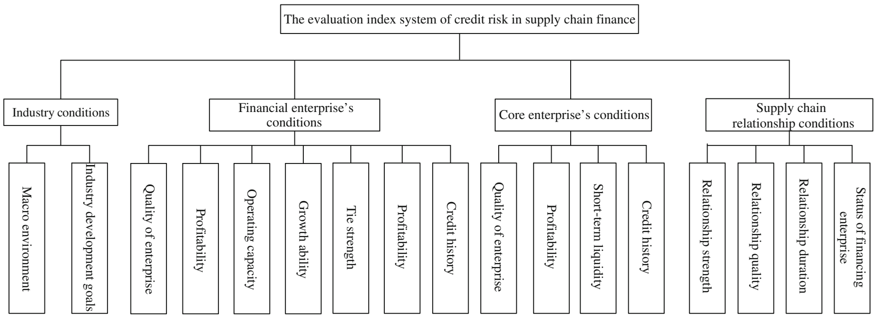


Fig. 153. 1 The index system of credit risk evaluation in supply chain finance

When evaluating the credit risk of supply chain finance, the main task is to decide the weight of these indices above. This article makes use of the evaluation model based on trapezoidal fuzzy number to decide the weight of these indices and then provide scientific basis for banks to evaluate credit risk in supply chain finance.

153.3.2 Credit Risk Evaluation of Supply Chain Finance

1. The fuzzy numbers used in this article are trapezoidal fuzzy numbers with specific definition (Neil et al. 2005) as follows:

We use $M = (m_1, m_2, m_3, m_4)$ to represent trapezoidal fuzzy number, and then its membership function is :

$$\mu_M(x) = \begin{cases} 0, & x < m_1 \\ \frac{x-m_1}{m_2-m_1}, & m_1 \le x < m_2 \\ 1, & m_2 \le x < m_3 \\ \frac{x-m_4}{m_3-m_4}, & m_3 \le x \le m_4 \\ 0, & x > m_4 \end{cases} \tag{153.1}$$

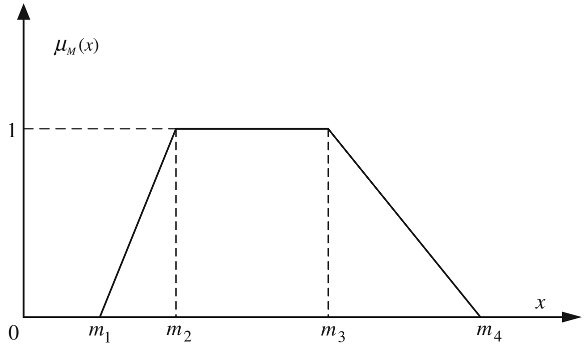
Among them, if $m_1 > 0$, then M is positive trapezoidal fuzzy number. And$m_1 < m_2 \le m_3 < m_4$, if $m_2 = m_3$, trapezoidal fuzzy number degenerates into a triangular fuzzy number. Specially, if$m_1 = m_2 = m_3 = m_4$, then M, as a trapezoidal fuzzy number, degenerates into an ordinary real number (Fig. 153.2).

2. The determination of the index weight.

(1) Determination of the trapezoidal fuzzy weight (Alexander 2002; Lili 2011)

(1) The establishment of the trapezoidal fuzzy matrix. Suppose that there are n experts to evaluate the m indices, and the four evaluations of index i by expert j are$\left[a_{ij}, b_{ij}, c_{ij}, d_{ij}\right]$, with $a_{ij} < b_{ij} \le c_{ij} < d_{ij}$. Experts give each index a mark in

Fig. 153. 2 Figure of trapezoidal fuzzy number



the interval from 0 to 100, and then form the initial evaluation matrix as follows:

$$M = \begin{bmatrix} [a_{11} \quad b_{11} \quad c_{11} \quad d_{11}] & [a_{12} \quad b_{12} \quad c_{12} \quad d_{12}] & \cdots & [a_{1n} \quad b_{1n} \quad c_{1n} \quad d_{1n}] \\ [a_{21} \quad b_{21} \quad c_{21} \quad d_{21}] & [a_{22} \quad b_{22} \quad c_{22} \quad d_{22}] & \cdots & [a_{2n} \quad b_{2n} \quad c_{2n} \quad d_{2n}] \\ \vdots & \vdots & \cdots & \vdots \\ [a_{m1} \quad b_{m1} \quad c_{m1} \quad d_{m1}] & [a_{m2} \quad b_{m2} \quad c_{m2} \quad d_{m2}] & \cdots & [a_{mn} \quad b_{mn} \quad c_{mn} \quad d_{mn}] \end{bmatrix} \tag{153.2}$$

(2) To obtain the weight set of expert evaluations $V = [v_1, v_2, \cdots, v_m]$, in which v_j means the proportion of the evaluation expert j gives to each index of the whole.
(3) Fuzzy synthesis. We use weighted average fuzzy operator to synthesize V and M, i.e. $V \odot M$. A is in representative of the synthetic fuzzy matrix, so namely $A = [[a_1 \quad b_1 \quad c_1 \quad d_1] \cdots [a_m \quad b_m \quad c_m \quad d_m]]$.
(4) To get the fuzzy weight. According to the characteristics of the trapezoidal fuzzy numbers, the fuzzy weight of index j can be set with $p_i = (a_i + 2b_i + 2c_i + d_i)/6$, then dealt with the normalized processing, so we can get the fuzzy weight set $W_p = [p_1, p_2, \cdots, p_m]$.

(2) Determination of entropy weight

Many supply chain finance credit risk evaluation indices belong to the class of qualitative indexes. With individual subjective opinion, to the same index, experts may have different evaluation results, so we can use the method of entropy weight to make appropriate adjustments. Entropy reflects the degree of the chaos of the system, the smaller the entropy value of the index, then the greater the variation, the more information it can provide, the greater the role that the index plays in the comprehensive evaluation, also the bigger the weight. Through the degree of variation, we can calculate the weight of each index. And the calculation process is as follows:

(1) Calculate the total entropy of each index. First, we should establish the trapezoidal fuzzy matrix, and then calculate the total entropy of index i according to M:

$$H_i = -\frac{1}{4\ln n}\sum_{x=a,b,c,d}\sum_{j=1}^{n}(x_{ij}\Big/\sum_{i=1}^{m}x_{ij})\ln(x_{ij}\Big/\sum_{i=1}^{m}x_{ij}\Big) \tag{153.3}$$

(2) Compute the entropy weight of index i. The entropy weight of index i is:

$$\eta_i = (1 - H_i)/(m-\sum_{i=1}^{m}H_i) \tag{153.4}$$

Thus, we can get the entropy weight set of m indexes:

$$W_\eta = [\eta_1, \eta_2, \cdots, \eta_m] \tag{153.5}$$

(3) Calculate the combination weight.

With analytic hierarchy process (ahp) as the example, the level weight set of supply chain finance credit risk evaluation system is $w_\alpha = [\alpha_1, \alpha_2, \cdots, \alpha_m]$, then the final weight of index i after the fuzzy entropy adjustment is:

$$w_i = (p_i\eta_i\alpha_i)\Big/\sum_{i=1}^{m}p_i\eta_i\alpha_i \tag{153.6}$$

Thus, we can get the final evaluation set: $W = [w_1, w_2, \cdots w_m]$.

153.4 Case Analysis

In the supply chain finance, when using trapezoidal fuzzy numbers to evaluate the credit factor of the core supplier in the supply chain, the bank mainly evaluates from the following four angles: the industry status, financing enterprises' status, core enterprises' status, and the supply chain status. Under the circumstances, the weight of the evaluations from 5 experts is $V = [0.24, 0.20, 0.17, 0.23, 0.16]$.

Experts work out four groups of possible data about the possibility of the above 17 Level-3 indices that may arise. The results are shown in Table 153.1.

The fuzzy weight, and entropy weight, also the weight of hierarchical authority can be confirmed by the method of the calculation of the entropy weight and triangular fuzzy synthesis method, as is shown in Table 153.2.

Finally, we can calculate the weight of these 17 indices as [0.0763, 0.0485, 0.0665, 0.0797, 0.0608, 0.0736, 0.0561, 0.0515, 0.0458, 0.0548, 0.0721, 0.0678, 0.0513, 0.0599, 0.0483, 0.0503, 0.0368].

Table 153.1 Experts' score of the weight of level-2 indices in the credit risk evaluation system of supply chain finance

Index	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
Macro-environment(C_1)	0.22,0.23,0.25,0.27	0.24,0.25,0.27,0.28	0.22,0.23,0.23,0.27	0.19,0.20,0.23,0.24	0.23,0.24,0.24,0.27
Industry development prospects(C_2)	0.24,0.25,0.25,0.26	0.27,0.28,0.28,0.29	0.23,0.25,0.26,0.28	0.21,0.24,0.23,0.26	0.27,0.28,0.28,0.30
Enterprise-basic quality(C_3)	0.39,0.41,0.41,0.42	0.36,0.37,0.37,0.39	0.34,0.36,0.36,0.37	0.30,0.35,0.35,0.38	0.28,0.30,0.31,0.36
Profitability (C_4)	0.36,0.38,0.39,0.42	0.33,0.36,0.36,0.39	0.32,0.33,0.33,0.35	0.30,0.31,0.35,0.37	0.26,0.29,0.36,0.38
Operating capacity(C_5)	0.37,0.39,0.39,0.44	0.34,0.36,0.38,0.39	0.33,0.37,0.37,0.40	0.30,0.33,0.35,0.36	0.27,0.28,0.28,0.32
Growing capacity(C_6)	0.35,0.38,0.38,0.43	0.33,0.35,0.35,0.37	0.32,0.33,0.33,0.38	0.31,0.33,0.34,0.36	0.30,0.31,0.33,0.35
Short-term liquidity(C_7)	0.39,0.41,0.41,0.43	0.37,0.39,0.41,0.45	0.32,0.36,0.37,0.38	0.35,0.37,0.39,0.40	0.33,0.35,0.35,0.36
Long-term liquidity(C_8)	0.38,0.39,0.41,0.43	0.36,0.38,0.38,0.40	0.35,0.37,0.37,0.42	0.33,0.34,0.36,0.41	0.28,0.29,0.35,0.36
Credit record (C_9)	0.37,0.38,0.38,0.42	0.35,0.37,0.38,0.40	0.34,0.37,0.37,0.39	0.33,0.38,0.38,0.39	0.35,0.37,0.38,0.39
Enterprise-basic quality(C_{10})	0.12,0.15,0.15,0.17	0.11,0.13,0.15,0.16	0.13,0.15,0.17,0.19	0.15,0.17,0.18,0.19	0.16,0.18,0.19,0.20
Profitability (C_{11})	0.13,0.15,0.16,0.18	0.12,0.15,0.15,0.18	0.14,0.17,0.19,0.20	0.11,0.15,0.16,0.18	0.13,0.15,0.15,0.19
Short-term liquidity(C_{12})	0.11,0.13,0.15,0.16	0.14,0.15,0.16,0.17	0.13,0.15,0.17,0.18	0.14,0.16,0.17,0.19	0.13,0.16,0.18,0.19
Credit record (C_{13})	0.13,0.15,0.16,0.17	0.11,0.13,0.14,0.17	0.12,0.15,0.16,0.18	0.16,0.17,0.18,0.20	0.14,0.16,0.18,0.19
Relationship strength(C_{14})	0.20,0.23,0.24,0.26	0.19,0.22,0.22,0.26	0.23,0.25,0.25,0.27	0.24,0.26,0.26,0.28	0.23,0.25,0.28,0.29
Relationship quality(C_{15})	0.24,0.26,0.26,0.30	0.24,0.28,0.28,0.31	0.22,0.24,0.26,0.29	0.23,0.26,0.29,0.30	0.21,0.23,0.25,0.26
Relationship long degree(C_{16})	0.22,0.25,0.25,0.27	0.24,0.26,0.27,0.29	0.20,0.22,0.24,0.25	0.21,0.24,0.25,0.28	0.24,0.26,0.28,0.31
Financing enterprise status(C_{17})	0.28,0.29,0.29,0.31	0.22,0.24,0.25,0.27	0.23,0.26,0.27,0.29	0.21,0.25,0.27,0.28	0.24,0.26,0.26,0.28

Table 153.2 The fuzzy weight, entropy weight, hierarchical authority weight

The fuzzy Weight	0.0508	0.0550	0.0774	0.0745	0.0756	0.0742
	0.0817	0.0788	0.0801	0.0340	0.0334	0.0332
	0.0336	0.0521	0.0559	0.0535	0.0563	
The entropy weight	0.0631	0.0599	0.0465	0.0481	0.0476	0.0480
Hierarchical authority weight	0.0439	0.0454	0.0445	0.0769	0.0775	0.0776
	0.0774	0.0622	0.0600	0.0613	0.0597	
	0.0760	0.0470	0.0590	0.0710	0.0540	0.0660
	0.0500	0.0460	0.0410	0.0670	0.0890	0.0840
	0.0630	0.0590	0.0460	0.0490	0.0350	

It can be seen from the sequence of the 17 indices, that among all the factors affecting the credit risk, the enterprise's profitability matters the most, and macro environment, growth capacity, and short-term liquidity are also important factors. While examining the credit risk of the supply chain finance, commercial banks should focus on the factors with large weight.

153.5 Conclusion

This paper transfers the language information evaluation given by experts into trapezoidal fuzzy numbers, and use the method of the trapezoidal fuzzy number combined with the theory of entropy weight to sort the weight of the 17 evaluation indexes of the supply chain finance. Through the case analysis, it can be seen that bringing in the trapezoidal fuzzy number and the theory of entropy weight can not only absorb individual expert's opinion, but also have the effect of balancing the evaluation results of all experts, which greatly reduces the loss of the decision information. By the comprehensive utilization of trapezoidal fuzzy numbers and entropy weight method to get the combination weight, the article not only retains much useful information in the quantification process of evaluating qualitative indexes, but also takes into full consideration the influence to the weight of index of discrete degree of the data, which makes the final index weight both subjective and objective, thus having greater practical significance.

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Chapter 154
Research on Vehicle Material Support Model Based on “Internet of Things”

Da-peng Zhang, Liang Wang, Feng-zhong Wang and Xiao-ping Kuang

Abstract The conception and the meaning of the “internet of things” are introduced in this paper. Related to integrative construction of vehicle material support, this paper builds a support model based on the analysis of the characteristics under the “internet of things”, which can make sense for the informatization construction of the vehicle equipment support system in theory and practice.

Keywords Internet of things · Informatization · Support model · Vehicle material

154.1 Introduction

As we all know that vehicle material supply is very important in the high-tech brushfire war. So a new vehicle material supply model based on the “internet of things” can fit the modern war pattern has been built.

In recent years, with the development of the information technology and network, the field of vehicle material supply has gone through drastic changes; the information collection, exchange and transfer for the vehicle material supply have become more and more efficient. Numerous vehicle companies and land force in various nations have undertaken major initiatives such as recombining efforts and investment in Information Technology (IT) to better manage their storehouse and reduce inefficiencies in their supply chain. However, little information showed that one challenge in all vehicle material support is the efficient management of

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inventory in a complex network of facilities and products with stochastic demand, random supply and high inventory and transportation costs, which have baffled the better management purpose in vehicle material supply chain. This requires us to start with information management of the vehicle material and to change the supply model. The appearance of the “Internet of Things (IOT)” makes it possible to come true (Chun-yan et al. 2011).

On the understanding that internet is the interpersonal communication by network, “internet of things” is a network which links all things together by information sensor equipment (such as radio frequency identification technology (RFID), infrared inductor, global orientation system, laser scanner and so on) and makes the communication expanded at “any time”, in “any place” and with “any person” to “human to thing” and “thing to thing”. And an intelligent supply system which can long-distance detect and control the material will be built based on the “Internet of Things”. So, in this paper, we build a vehicle material supply model based on the “Internet of Things” (International Telecommunication Union. ITU Internet reports 2005).

154.2 The Trend of Vehicle Material Support Model Based on “Internet of Things”

154.2.1 Informatization and Intellectualization

In the future war, the core and soul of vehicle material will contain three steps: information resource, command and controlling, and survivability, which are decided directly by the content of informatization and intellectualization. Firstly, information is the most important invisible resource in vehicle material support, which can guide the whole process of material support including preparing, planning, organizing and implementing. Vehicle material support needs cooperation of logistic activities and information streams to make supportability. Secondly, intellectualization is the core of vehicle support’s command, controlling and correspondence. In the data battlefield of future, vehicle support could realize the intellectualization and network of command and correspondence by “internet of things” system, which transmits the vehicle material information such as storage, transportation, fuel loading and consumption with current data and images to every visible system, and the commander can control material states such as production, storage, transportation and supplement etc. directly and give command precisely.

IOT information platform has provided with the commander with great support. With its support, the commander can intellectualize the control and commanding of vehicle material by mastering the consumption of vehicle material, the amount of time, space, species and quantity that vehicle material needs, proper dispatching, automated selection of secured routes, automated decision of solutions, etc. (Wamba et al. 2006).

154.2.2 High-Speed and High Efficiency

High-speed and high efficiency make the vehicle support decisive and efficient in modern wars. One reason is that only the high-speed support can adapt to the cadence of the informatization war, and with the improvement of support speed and efficiency to a large extent, the supplement of vehicle material can be timely and in place (Bottani et al. 2009). The other reason is that quick reaction achieves high efficiency. The extensive application of "internet of things" technology will lay the foundation for high speed and high efficiency of vehicle support. At the same time each factor of the safeguard for vehicle materials will change at all: on the facet of the transmission and disposal of vehicle material support, data communication and automatic command system will achieve the transmission and disposal of the information; on the facet of organizing and command, computer simulation technology can predict the amount of the demand and make support plan quickly according to the factors like model, scale and geography of the battlefield, which cuts down the command and decision time largely; on the facet of storage of vehicle material, it can adjust the changes of environment and the mission (Thiesse and Condea 2009).

154.2.3 Omnidirectional and Integrative

The unity and integration of modern war gets the vehicle material support to develop towards omnidirection and integration. On the one hand, the frontispiece and depth of vehicle material support will be larger and larger with the development of warfare ability, mode and means, and flat line style would be replaced by solid network. Only if we have an omnidirectional vehicle material support can we adapt to the informatization battlefield. On the other hand, the informatization war is a kind of united warfare with multi-service joint operation, and the informatization command and warfare system will combine all kinds of multi-service battle effectiveness together into one unit (Wang et al. 2010). We will not meet the needs of combined operations without the integrated support. Therefore, the vehicle material support system has to break the borders of army services, integrate organization and command as one, and optimize the deployment and vehicle material resource in general. The appearance of "internet of things" will realize the integration and digitalization of vehicle material support, combine the support forces of all army services into one unit, and also combine storage support forces of front-line and back-line, which could provide conditions for integrative vehicle material support (Giusto et al. 2010).

154.3 The Design of the Vehicle Material Support Model Based on "Internet of Things"

154.3.1 The Real-Time Information Disposal Systems

The management doctrine of the USA United Air Lines is "the right parts, to the right aircraft, at the right time-at the lowest possible cost." This doctrine explains the relationship between vehicle material cost and support effectiveness incisively: the lowest cost and provision assuring the supply of vehicle materials. The key sections below should grasp skills of the safeguard for vehicle materials: whole support total safeguard for vehicle materials, the importance of planned stockpile, cycling period control, quality assurance, continual cleaning up of remainder, making real-time disposal and decision on support information (Wamba and Lefebvre 2006). As a result, a support model based on "internet of things" should build up an efficient information platform (Fig 154.1) for vehicle material support at first. According to characteristics and requirements of data transmission in support system, making use of this information platform and, acquire, identify,

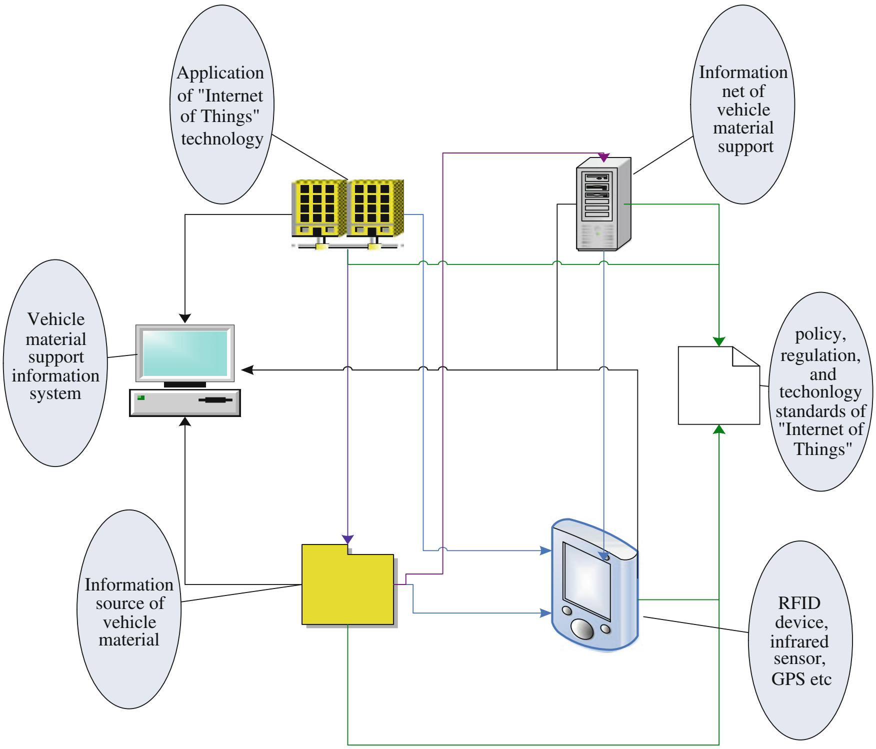

Fig. 154.1 Vehicle material support information platform based on "Internet of Things"

dispose, transit, transmit, memorize, use and control support information effectively, then transform into energy to make a great benefit quickly (Dejin and Rosson 2009).

As every step during support is in the condition of motive or friability, the information and direction always shift with actual actions in time and space, which would affect the availability, sharing, instantaneity and accuracy (Maekawa et al. 2009) of the information. Vehicle material support system bases on "Internet of Things", which could solve these problems effectively. It could use the information platform to make the "internet of things" be widely used in many occasions," such as storehouse management, transport management, production management, material track, means of delivery and shelf identification (Kaus and Podladchikov 2001). It is shown in Fig 154.2.

(1) Spare parts production enterprises of vehicle material. The platform will display spare parts production factories, enterprise network charts according to requirement, and locking the factory of a certain spare part, show its location, which provides information for raising material to leaders in the warfare, and meet requirement of vehicle material.
(2) Spare parts storage enterprises of vehicle material. The system will switch to network chart of spare parts storage automatically according to requirement

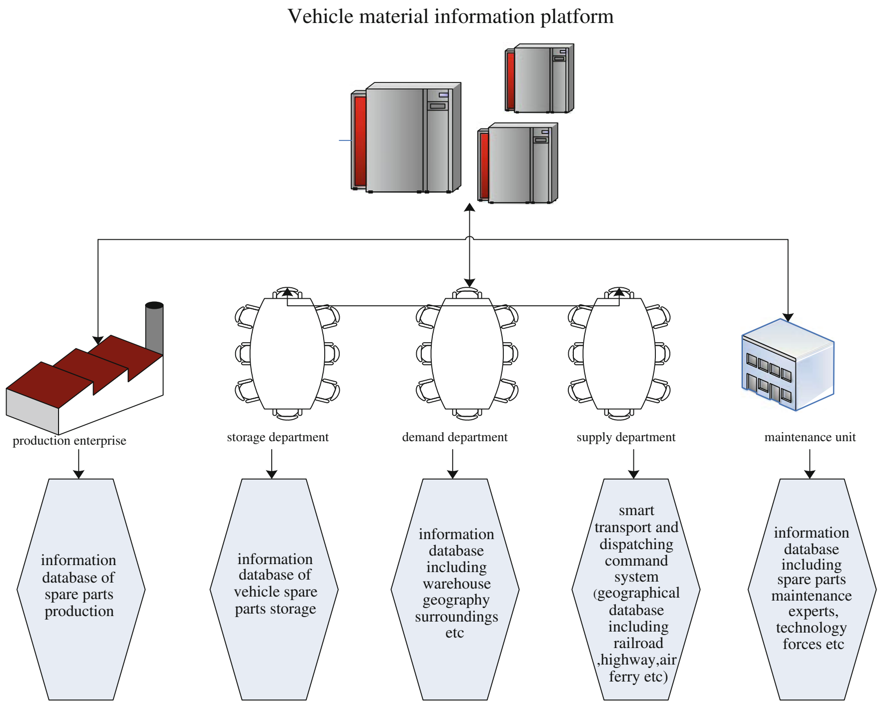

Fig. 154.2 Sketch map of vehicle material support system network

information, and present optimal storage information of spare parts based on "handy principle". Then display the distance from storage point to requirement point (Waldrop et al. 2003).

(3) Demand department of vehicle material. Providing the information such as location, characteristics, vehicle modes and the number etc.

(4) Supply department of vehicle material. After the storage point and the requirement point are confirmed, the system will create provision route network chart to fix optimal transport plan.

(5) Maintenance units which consume the vehicle material. If there is no storage of spare part and material that could be repaired, the system will provide reference information to display maintenance department, maintenance expert and maintenance capacity, which assists management leaders to make decision of organizing repairing of vehicle material rapidly (Zhou and Wang 2004).

154.3.2 Integrative Support Model for Vehicle Material

The support of vehicle material should not only provide material and money to support objective, but also meet its demand using informatization support technology, means and method. With adoption of advanced information technology, an information system for equipment support should be founded due to the profound principium of vehicle equipment, its complicated structure, and its changeable support means and content. Then it can improve the efficiency and effectiveness of equipment support (Weis 2003). As a result, the idea and the technology of "Internet of Things" will make an immeasurable influence on the command, the process and the technology method of the information development. Aimed at the characteristics of supply chains we could design a model as shown in Fig. 154.3.

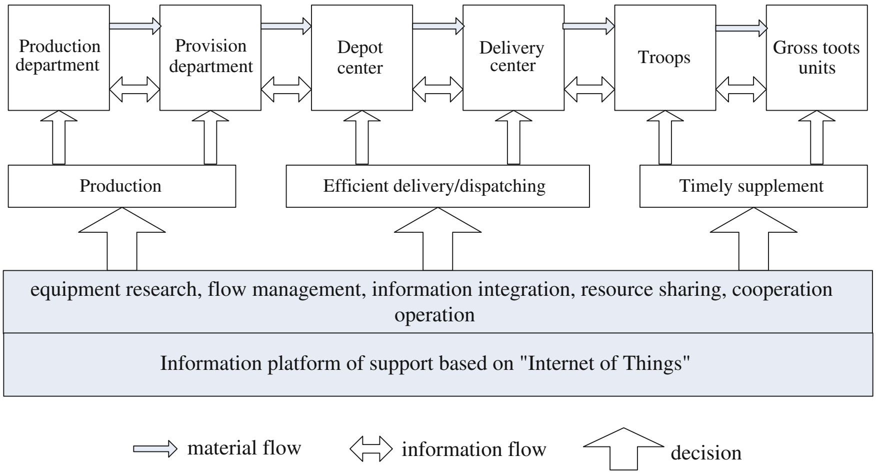

Fig. 154.3 Real-time integrative vehicle material support model

The value of integrative vehicle material model is that we can extract the information we need from data by "Internet of Things" including information based on geographical space and place, information on product attribute, production flow condition, supply chain key indices and data flow speed etc. The "intelligence" supply chain of "Internet of Things" age could meet the need of informatization vehicle material support, enhancing its efficiency (e.g. dynamic supply and demand balance, detection and solving of predict accidents, aimed at reducing stockpile level and product position visualization etc.) and also reduce conserving pressure of supply chain (e.g. reducing the consumption of energy and resource, reducing the pollution of exhaust emission) (GS1 EPC global.EPC Information Services (EPCIS) Version 1.0.1 Specification Errata Approved by TSC on September 21 2007). Right now the factors such as prolix and low effective infrastructures, high stockpile cost and low load efficiency have severely affected the function of supply chain network. The "intelligent" supply chain of vehicle material would optimize the supplying model from raw and processed material to product through powerful analysis and simulated engine. This would assist factory to make sure of the product facility location, optimize material storage place, and set stockpile distribution strategy. Furthermore, a "internet of things" would make the real seamless, end to end supply chain come true, it will reduce capital and cost (transport, storage and stockpile cost), at the same time, heighten control capacity of vehicle material support.

154.4 Conclusion

The application of "Internet of Things" in vehicle material support will make the safeguards for the environment more transparent, support resource more timely and support model more efficient on the condition of informationization wars, which make great sense to informationization construction of Land Force.

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Chapter 155
"Transportation Management Practices" Systematic Course Model Based on the Integration of School and Enterprise

Li-juan Que and Hui-yun Gao

Abstract "Transportation management practices" plays a vital role in cultivating talents as a logistics management professional core course. In the light of deficiency of traditional teaching model and the teaching reform of the course, this paper proposed a new systematic course model of "transportation management practices" based on the school-enterprise integration. The paper mainly discussed the course orientation, course content, classroom implementation and teaching evaluation. Finally, the implementation effects of systematic course model were elaborated.

Keywords Course model · Integration of school and enterprise · Logistics management · Systematization · Transportation management practice

155.1 Preface

In 2009, the State Council listed logistics as one of the ten major revitalization industries, while logistics industry is badly in need of a large number of highly skilled talents. As the most important professional course of core technology in logistics management, "transportation management practices" is essential to logistics personnel training. Because the traditional teaching model is difficult to adapt to the social demand for logistics professionals, integration of school and enterprise course design emerges as the require of times. Based on the integration

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of school and enterprise, "transportation management practices" systematic course model plays an important role in logistics personnel training and the development of the logistics industry (Da-yuan 2005).

155.2 "Transportation Management Practices" Course Model Overview

155.2.1 "Transportation Management Practices" Course Based on the Integration of School and Enterprise

The so-called integration of school and enterprise refers to the integration of the course orientation and enterprise post, course content and work content, school teachers and enterprise teachers, course evaluation and enterprise standard in the "Transportation management Practices" course.

In the "course orientating", based on fully analyzing transportation management post group of enterprise, we determine the course orientation and objectives in view of the posts which the higher vocational graduates can meet. In the content of the course design, the work content is transformed into learning content after full investigation about transportation work content in enterprises; in the aspect of teaching practices, school teachers and enterprise teachers together design the course and teach students; in the course evaluation, the transportation management business standards are introduced into it so as to ensure the students to meet the requirements of enterprises (Wang 2007).

155.2.2 The Systematic Course Model of "Transportation Management Practices"

According to the system theory, the local optimum does not represent the overall best. From the overall concept, according to the laws of cognition of students, the system reflects the level of students that is from simple to complex, gradual spiral, and easy to deep. According to the transportation business relationship, "Transportation management practices" course carries on systematic orientation of the various modes of transport. The course is designed as six learning tasks including establishing an overall framework of transportation management (Zhi-qun 2003), handling business of carload freight transportation, less-than-carload freight transportation, special cargo transportation and multimodal transportation, and designing comprehensive shipment planning in light of the business of a transport position from beginners, skilled workers to experts (Ting-fang 2011).

155.3 The Orientation and Objectives of the "Transportation Management Practices" Course

This course is integrated with course orientation and job posts. For transportation management, there are many job posts, including the commissioners, competent assistants, supercargoes, bill clerks, statisticians, dispatchers and managers of transportation. The students of higher vocational education are corresponding to the job of dispatcher and manager of transportation based on enterprise survey and enterprise expert seminar (Zou and Bin 2007).

Taken the business requirements of the post and the long-term development of students into account and combined with professional training goals, the ultimate orientation of the "transportation management practices" course is to train highly skilled dispatchers and managers of transportation in the forefront (Fa-zhi 2011).

We determine the following eleven objectives according to the course orientation. The objectives are that students can ensure the safety of goods, plan route, select the appropriate mode of transport, select the appropriate transport tools, handle general and special goods transport business, handle multimodal transport business, calculate shipping costs correctly, resolve transport accidents and disputes, add up and analyze of transportation data and design transportation plans (Xu 2006).

155.4 Design the Content of "Transportation Management Practices" Course

155.4.1 Course Content

Through enterprise survey and enterprise expert seminar, we consider the logistics management professional standards and the course objectives. And then, sort the typical work contents from simple to complex and transform them into learning tasks (Yao 2007). Specific learning tasks in this course are shown in the following Table 155.1:

155.4.2 Characteristics of Course Content

When designing the course content, we break the traditional classification mode of transport such as roads, railways, waterways, aviation and integrate course content with word content. So the content reflects business systematization. The main course characteristics are as follows:

Table 155.1 Comparison of work contents and learning tasks

Post development level	Capability level	Work content	Learning task from work content
Beginner	Cognitive capability	Understanding transport operations	(1) Establishing overall framework of transportation management
Skilled worker	Operational capability	Operating specific business of transportation	(2) Handling carload freight transportation business (3) Handling less-than-carload freight transportation business (4) Handling special cargo transportation business (5) Handling multimodal transportation business
Expert	Decision-making and planning capability	Making decision and planning for transportation	(6) Designing comprehensive shipment planning

(1) *Course content is based on complete working tasks.* The course content takes complete working tasks of transportation as a carrier, and integrates theory with practical knowledge. So the context of each learning task comes from the actual task. In order to develop students' comprehensive professional abilities, every learning task is a complete task which reflects a complete business process.
(2) *Follow laws of the learners' cognition.* On designing the course content, the relationship between each learning task is a progressive relationship, which is from simple to complex and easy to deep. So the order of learning tasks reflects the "cognitive capability—operational capability—decision-making and planning capability" progressive processes, that is to say, it follows the laws of career growth from beginner, skilled worker to expert (Fu et al. 2011).
(3) *Each complete learning tasks has a common business process procedure.* Common business process procedure can make learners repeat the basic work steps and strengthen basic work steps and attitude. While the complexity and theoretical height of each learning task increasing, the learners' transportation management capabilities are improved. The common business process procedure of learning task is "receiving task—making plans—fining information and related basis—identifying specific ways—related business simulation and operation—feedback and evaluation"
(4) *Learning content is appropriately a little more than work content.* Taking into account the students' future career development, the design of learning content will be appropriately more difficult and complex so that the students can have more space in the enterprise after graduation. For example, the "designing comprehensive shipment planning" learning task comes from but more difficulty and complexity than actual work.

155.5 Classroom Implementation of "Transportation Management Practices"

Good teaching content designing can help the students reach the desired objectives only if good classroom implementation. Classroom implementation of "transportation management practices" reflects the integration of school teachers and enterprise teachers. The characteristics are as following:

155.5.1 School Teachers and Enterprise Teachers Jointly Design and Implement the Course

The course content is jointly developed and designed by school teachers and enterprise part-time teachers. For example, the last learning task which is the most comprehensive and difficult project, we use the real designing project on enterprise, and we invite enterprise teachers to teach the students and evaluate their plans according to enterprise standards (Ni 2008).

155.5.2 Teachers Make Students Play a Main Role in the Classroom and Set Up "the Ladder" for Them

In the process of course implementation, we must analyze the basis of students at first, and then combined the course learning objectives with the designed learning tasks for students in order to set up "the ladder" for them to complete the task successfully. "The ladder" here means students' self-learning materials which can help them achieve the desired learning objectives independently through self-study. Those materials include project instructions, learning pages and so on. When designing those materials, we pay special attention to the relevant theoretical knowledge in order to achieve the combination of engineering design projects.

155.5.3 Teachers Play the Dominant Role and Direct Students

In this new teaching model, teachers play a role as the organizer, consultant, mentor, companion and evaluator. Then teachers' main work is as following: First, teachers lead the path for the students through designing classroom activities and writing detailed lesson plans. Second, teachers help students reflect on learning and summarize the theory through preparing presentation materials for them. Third, teachers design classroom assessment programs, daily evaluation form, examinations and skills tests to validate teaching objectives. At last, teachers improve and refine the teaching by the way of writing teaching analysis and teaching reflection (Peng 2006).

155.6 Course Evaluation of "Transportation Management Practices"

155.6.1 Course Evaluation Program

Referring to the standards operating requirements of transportation management, experts from industry and enterprises participate in personnel training and evaluation. This course evaluation reflects the integration of curriculum evaluation and enterprise standards which is a combination of theory and practice (Li 2011). The composition of the total score is shown in the following Table 155.2:

155.6.2 Characteristics of Course Evaluation Program

(1) *Diversification of evaluation subject.* This course takes the form of "teacher evaluation plus enterprise part-time teacher evaluation plus student evaluation

Table 155.2 Composition for total score of "Transport Management Practices"

Project number	Project name (learning outcomes)	Score
1.	Establishing overall framework of transportation management (Research report and presentation material)	10
2.	Handling carload freight transportation business (Simulated operation records, Learning page and presentation material)	10
3.	Handling less-than-carload freight transportation business (Simulated operation records, Learning page and presentation material)	20
4.	Handling special cargo transportation business (Simulated operation records, Learning page and presentation material)	10
5.	Handling multimodal transportation business (Simulated operation records, Learning page and presentation material)	20
6.	Designing comprehensive shipment planning (the designed scheme—bid book, Enterprise expert evaluation)	30
7.	Mid-term assessment (a big job)	100
8.	Final assessment (test papers)	100
Total score = ($\sum$project 1 + project 2 + …… + project 6) *60 % + mid-term assessment *10 % + final assessment *30 %		100

(including student self-assessment and peer assessment)" to evaluate the students. Enterprise part-time teacher evaluation is from the point of actual enterprise work to evaluate students' learning outcomes.

(2) *Visualization of the evaluation object.* Teachers evaluate students' visual results, which include research reports, presentation materials, operation records, learning pages, reporting PPT, audio and video information and so on. They also make teaching reflection and evaluate their teaching effectiveness based on the feedback of students after-school.

(3) *Integration of course evaluation.* The evaluation consists of theoretical and practical assessment, focusing on evaluation of students' ability enhancement. And it reflects an evaluation of student's comprehensive professional competence, which includes professional, social and methodological competence.

(4) *Evaluation criteria from enterprise.* We introduce industry and position assessment criteria for transportation into course evaluation as an important part of evaluation standards of student.

155.7 Implementation Effects of the Systematic Course Model of "Transportation Management Practices"

Based on the integration of school and enterprise "transportation management practices" systematic course model, the teacher become an organizer, consultant, mentor, companion and evaluator of the learning process from the role of traditional knowledge transporter, so that we can transform the teaching process into learning process of students by themselves. We have gotten good teaching effect from teaching practices.

155.7.1 Increased Initiative and Enthusiasm of Students

Students experience the joy of success and establish self-confidence in a group study, work training & exhibition, and then stimulate students' enthusiasm of learning to the maximum.

155.7.2 Fully Developed Students' Compositive Professional Competence

It follows the basic law of students' vocational ability training on course content selection and arrangement. The learning content reflects an integration of theory and practice, schools and enterprises, and reflects the "simple to complex, easy to deep" systematic thought. The implementation of "teaching, learning and doing" integrative teaching method cultivated the students' professional competence.

Group learning cultivates a spirit of teamwork and the sense of competition. Learning appropriately a little more than the actual work content cultivates the students' capacity for sustainable development. And designing comprehensive shipment planning independently cultivates a sense of innovation and innovative capacity of students. These compositive professional competences make the students popular and laid a solid foundation for future work and development of the students.

155.7.3 Improved the Teaching Level of Teachers

In the new model of course, teachers not only focus on teaching basic theory, basic techniques and basic methods, but also pay attention to cultivating students' thinking ability, communication skills, teamwork, innovation and design capabilities. So they have to use a variety of teaching methods and means to enhance students' knowledge, ability and quality levels. In the new mode of course, teachers need more efforts and need to have a more comprehensive professional knowledge and teaching skills. While developing students' professional competence, their professional and teaching levels are improved.

155.8 Conclusion and Prospect

The integration of school and enterprise "transportation management practices" systematic course model fully developed students' compositive professional competence and improved the teaching level of teachers. We need to improve the more details of this course model in order to get better learning and teaching effectiveness and train a large number of transportation management talents.

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Chapter 156
The Existing Problems and Construction Scheme of the Green Supply Chain in Coal Chemical Enterprise

Ye-jun Wang and Xiang-jing Luan

Abstract In this paper, we analyze the existing problems of the green supply chain management in coal chemical enterprise, and then, we try to dissect reason and design a construction scheme about the green supply chain management of a chemical enterprise.

Keywords Coal chemical enterprise · Green supply chain · Sustainable development · Performance evaluation

156.1 Introduction

Since 1990s, the enterprise competition gradually entered into the era of supply chain competition (Webb 1994). Enterprise gradually becomes from facing the market competition to facing the Supply chain competition. For example, Hebei province is one of the provinces which have lots of coal industries, But, when the coal industry gain the competitive advantages through the supply chain, in the same time, it also consumes lots of resources and makes a huge damage to the ecological environment (Tyler 1995). So, building and implementing green supply chain management (GSCM), becomes the key link to gain the competitive advantages for the coal chemical enterprise (Sarkis 2008).

The existing problems of the green supply chain management in coal enterprise:

Firstly, the coal chemical enterprise is still staying in the traditional purchasing stage when purchasing, they usually ignore the environmental friendly indicator, energy consumption, etc. So, it is difficult to control the purchased product' green degree; in the same time under the simultaneous purchase mode, purchasing

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department ignore the change of production process, production schedule and product demand, thus cause long purchasing cycle and low efficiency problems (Liang and LiChen 2008).

Secondly, in the production course, the green degree is lower. Designing the product, we always consider cost, quality, product function and so on, and ignore the negative influence, like environmental pollution, the consumption of energy, etc. (Leena 2008); The subject of the self-conducting logistics for production logistics mode, leads to the high logistics cost, low efficiency, low green level.

Thirdly, in the marketing process, the green level is lower. In the marketing, the low information sharing rate among supply chain enterprise and the sufficient information communication and sharing make part goods do not match customer requirements any longer, thus lead to the higher product costs and lower green levels (Zhu and Sarkis 2006).

156.2 Methodology

On the basis of qualitative analysis, this article use Fuzzy-AHP to make the GSC performance evaluation for the coal chemical enterprise in Hebei province. This method is not only to find problems, but also to target to improve. As a result, promote enterprises supply chain of green development.

The process is shown in Fig. 156.1:

In this paper, combined with the specific characteristics, we firstly construct the evaluation index system according to the principle of index system of evaluation. The evaluation index system includes six one-class indexes and twenty-six secondary indexes.

The table is shown in Table 156.1:

Secondly, we can calculate the indexes weight by constructing the judgment matrixes.

Thirdly, we calculate the GSC performance index membership grade (Sarkis 2008).

Fourthly, we can make the single factor and multi-actor evaluation by establishing the fuzzy relation matrix. In the end, we can get the results of evaluation of the coal chemical enterprises.

156.3 Results

According to the above the evaluation process, we can get the comprehensive performance evaluation of GSC of the chemical enterprise is 75.9, which is over 70 score. This means that GSCM of the enterprise in the Hebei province is a medium level. But it is not optimistic because one-class indexes score of “sustainable development”, “Environmental performance” and “Cost” are 66.7, 58.9,

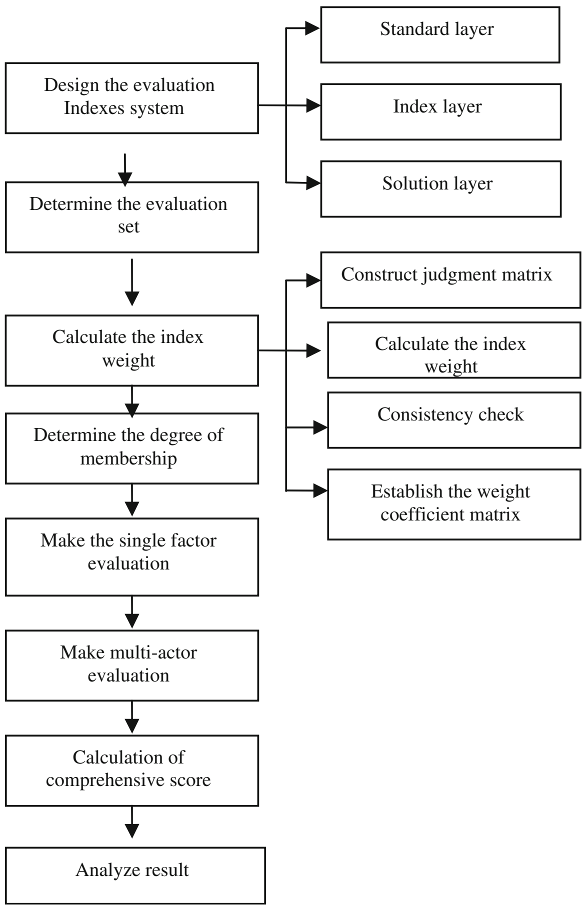

Fig. 156.1 Fuzzy-AHP basic procedure

69.2, which is lower than 70 score. Through the thorough analysis, we find that Secondary indexes such as "Waste recycling", "Emissions", "Raw material and resource utilization", "Scientific research investment rate" and so on lead to the three factors lower than the industry standards. As a result, we must start to analysis environmental performance, cost and sustainable development in order to construct GSCM of the coal chemical enterprises successfully, and then we can take measures to improve (Otto and Kotzab 2003).

The Design of Green Supply Chain in coal chemical enterprises:

156.3.1 Construction of the Green Procurement Program

(1) Choice of green materials. High quality coals can not only improves product quality, reduces environment pollution, reduces raw material usage, but also

Table 156.1 Making GSC performance appraisement index system

Target layer	Standard layer	Index layer
GSC evaluation result	Business process B_1	Raised production capacity rates C_1
		Waiting order ratio C_2
		Supply chain information sharing rate C_3
		Product qualification rate C_4
		On-time delivery rate C_5
	Financial value B_2	Profit growth rate C_1
		Asset liability ratio C_2
		Return on equity C_3
		Sales profit margins C_4
		Total asset turnover C_5
	Cost B_3	Human resource cost C_1
		Logistics cost C_2
		Information cost C_3
		Waste processing cost C_4
		Asset cost C_5
	Customer service B_4	Market share C_1
		Customer response time recognition rate C2
		Shortage frequency C_3
		Complain response time C_4
	Sustainable development B_5	R & D investment rate of return C_1
		The proportion of scientific research personnel C_2
		New product yield C_3
		Scientific research investment rate C_4
	Environmental performance B_6	Raw material and resource utilization C_1
		Emissions C_2
		Waste recycling C_3

can save energy and reduce the "three wastes" emissions, effectively prevent corrosion of process equipment (Stevels 2002).

(2) Establish and develop strategic partnership with suppliers. Good relations of cooperation will not only help suppliers to provide qualified products according to the requirements of coal chemical industry, but also take the constraints of the green supply chain into account in the design and before taking green products into mass production, it can make product cleaner and better quality (Petrovic 2001). Coal chemical enterprises conduct technical training for suppliers, and make to win situation with the company to establish strategic cooperative relations by providing financial resources.

(3) Build a unified procurement platform. Coal chemical enterprises can use the methods of "intensive" to purchase, it means making the decentralized procurement projects focus on harmonization of procurement by the department of purchasing corporation (Weber 2000). Coal chemical enterprises can obtain economies of scale, at the same time they can increase the level of green procurement logistics by a reasonable classification of the procurement.

156.3.2 Construction of the Scheme of Green Production

(1) The implementation of green design and cleaner production. Coal chemical enterprises should introduce new technology and new materials, etc. and basing on "reduce, reuse, recycle." principle of circular economy. Coal chemical enterprises should strengthen the implementation of green design and cleaner production.
(2) Improve the degree of green logistics. Coal chemical enterprises should take a different approach for different categories which are based on the item's features, performance and strengthen the construction of green storage. The enterprises can further enhance the level of storage while ensuring the production through the design of safety stock. At the same time, they should strengthen the care and maintenance during storage and make good explosion-proof, moisture, corrosion, waterproofing, leak-proof and so on (Clift and Wright 2000).

156.3.3 Construction of the Green Consumption

(1) Give correct guidance of green consumption. Firstly, the Chemical enterprise should makes the sales staff know the green sales idea and green product environmental protection, Then through the varieties of publicity approaches and communication methods, we can change the customers' demand of life or production environment quality into the dominant actions which is useful for environment promotion (Persson and Olhager 2002). Through network implementing on-line sales, enterprise can help the purchaser to understand the green value quickly and accurately, and then give the correct guidance of green consumption.
(2) Make the green package. Enterprises should take the economic principles of "reduction", "reuse", " recycling" into accordance, negotiate with the upstream and downstream firms to make sure the products packing, achieve the goal of moderate packaging, flexible packaging and recycle packaging, In the premise of product quality, we try to use "nullity packing", reduced packaging or circulating packaging as far as possible, and choose the green packaging materials (Johnson 1998).
(3) Carry out joint distribution to improve sales logistics green degrees. Chemical companies need to establish a quantitative mode for sales logistics management, through the methods of "large delivery cut the fees" and "containerization cargo cut the fees" to achieve logistics rationalization. Meanwhile, through the joint with other enterprises, develop a common distribution business to improve the distribution logistics' green level.

156.3.4 Construction of Waste Recycling Scheme

(1) Strengthen the construction of waste recycling system. Chemical enterprise should unite other enterprises, which are in or out of the supply chain network to establish a waste recycling system (Beamon 1999). Then waste materials of the end could be back into the supply chain, thus can reduce the environment pollution and improve resources recycle rates effectively.
(2) Strengthen the recycling rates of waste solid. At the end of the chemical enterprise production, the solid waste is mainly fly ash. The enterprise can establish a comprehensive utilization of coal ash production engineering, using fly ash to produce Portland cement by confecting method, to realize the goal of low cost, low pollution, but high effect, high production.
(3) Strengthen the recycle of industrial waste air. The mainly of industrial waste air in coal chemical industry enterprises are NXO, aromatics, SO_2, coke oven gas, etc. The enterprise can introduce advanced technology, transfer production process, purchase environmental protection facilities, to reduce the gas production effectively. We can use coke oven gas to produce methanol or to conduct electricity, then make new profit growth points (Handfield 1997).

In short, for promote the sustainable development of coal industry, establishing and enforcing GSCM has practical value. And for promote social economy's development rapidly and healthily, building and implementing GSCM can also play a positive role.

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Chapter 157
Analysis of Untraditional Risks Based on Data Mining

Zhong Ning, Yue Yang and Tong Liu

Abstract Customs development is not only faced with traditional security risks but also the threat of more and more non-traditional security factors are exacerbating the risk of customs operation. In this paper, data mining (Data Mining) are used for the analyzing for a large number of customs data. And this paper further explores the neural network model in the customs of non-traditional security issues in the applicability of risk. Obtained through research, data mining technology is an excellent study to the future non-traditional security issues and it provides a certain methodological basis to future research.

Keywords Data mining · Non-traditional security · Risk management · Neural network

157.1 Introductions

In recent years, with the accelerating process of economic globalization, international and domestic factors required customs to perform a new more non-traditional functions. The customs are facing increasing, expanding non-traditional challenges of functional tasks.

In the 1970s, some American scholars have proposed the concept of non-traditional security and non-traditional security as defined in the scope, nature, and the difference between traditional security and contact. The late twentieth century early twenty-first century, on the study of non-traditional security issues unfolding. Since

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the events of September 11 and SARS incident, the non-traditional security issues are very big concern. Thurman, Mathias, Emshwiller, who proposed a customs facing non-traditional security factors. Rosencrance mentioned that the information technology and customs relations between non-traditional security risks (Easley and Martin 2006). In recent years, with the non-traditional security threat to China's expanding domestic academic research on non-traditional security has been significantly strengthened, some scholars such as Yu, Lin, Zhou introduced Shakespeare and other "non-traditional security" concept and issues the background, "non-traditional security" features, and non-traditional security and responsible image of the building and focuses on building a big country and the role and image of the proposed "non-traditional security maintenance," the Chinese way (Hodge 1997). Although many scholars have put forward at the strategic level, China's response to the idea, but at the technical level of the application has few, for the customs of non-traditional security functions, and even less (Koenig-Archibugi 2004). Chinese customs functions of traditional security is already quite mature, instead of the traditional security functions has not yet attracted sufficient attention (Thurman et al. 1996).

157.2 Data Mining

Data Mining (Data Mining), is stored in the database from the data warehouse or other repository of large number of According to obtain valid, novel, potentially useful and ultimately understandable patterns in the process (Berry and Linoff 2009). In many cases, data mining, also known as knowledge discovery in databases. Knowledge discovery in data mining are the most important part, to technical terms, it refers to a wide range of data extracted from the mining of a large number of unknown and valuable knowledge of the mode or law of other methods (Giudici and Figini 2009), which include related rules, time series, artificial intelligence, statistics, databases, etc. Found out from the knowledge database can be used in information management, process control, scientific research, decision support and many other aspects.

Traditional data mining and data analysis (such as query, reporting, on-line application analysis) is the essential difference between data mining in the absence of clear information of assumptions go digging and found that knowledge (Han et al. 2011). Data mining has received information previously unknown, the validity and usefulness of the three characteristics. Previously unknown information is the information had not been anticipated in advance, that data mining is to find those who can not rely on intuition or knowledge of information found, and even counterintuitive information or knowledge, and tap out the message that the more unexpected, may be more valuable (Rosencrance 2001). Therefore, the data mining analysis of the data than the traditional customer loyalty is more suitable for this exploratory study of the problem.

157.3 Classification Based on Back Propagation Method of the Customs Classification of Non-Traditional Risk Analysis

Back propagation neural network is a learning algorithm. Neural network is a set of connected input/output unit, in which each connection associated with a weight. In the learning phase, by adjusting these weights to predict the correct input tuple class label.

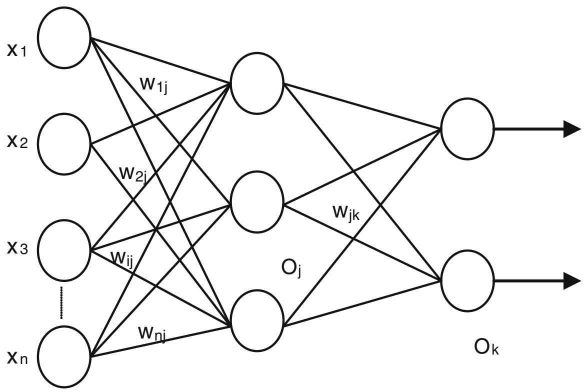
157.3.1 Multi-Layer Feed Forward Neural Networks

Back propagation algorithm in multilayer feed forward neural network learning. It iteratively learns to class label for the tuples of a set of forecast weights. Multilayer feed forward neural network consists of an input layer, one or more hidden layer and output layer. Examples of multi-layer feed forward network shown in the Fig. 157.1

Each is composed of a unit. Network input training tuple corresponding to each measured attribute. Provide input to the cell layer called the input layer. These input through the input layer, and then weighted the same time called the hidden layer provides a "class of neurons," the second layer. The hidden layer unit of output can be input to another hidden layer, and so on. The number of hidden layer is arbitrary, although in practice usually only one level. Finally, a hidden layer of the composition of output as the weighted output is input layer of the unit and released to the output layer of network prediction given tuple.

Input layer of the cell are called the input unit. Hidden layer and output layer unit, due to their biological basis of the symbol, sometimes called neuroses, or said output unit. Figure 157.1 shows the multi-layer neural network with two output units. Thus, they are called as two neural networks. (Do not remember the input

Fig. 157.1 Multi-layer feed forward neural networks



layer, because it used to pass input values to the next level). Similarly, the network contains two hidden layer neural network called the three, and so on. The network is feed forward, if its weight is not back to the input units, output units, or the previous layer. Network is fully connected, if every unit down to a layer of each unit to provide input.

Each output unit before taking the weighted sum of the output layer unit as input (see Fig. 157.1). It will be a non-linear (excitation) function acting on the weighted input. Multilayer feedforward neural network can predict the class as a non-linear combination of the input model. From a statistical standpoint, they are non-linear regression. Given enough hidden units and enough training samples, multi-layer feed forward network can approximate any function.

157.3.2 Defining the Network Topology

How involved in neural network topology, at the beginning of training, the user must specify the unit number of input layer, hidden layers (if more than one layer), the number of units for each hidden layer and output layer unit number, to determine the network Topology.

Tuple in the training of each attribute value is normalized by measuring the input help to speed up the learning process. Typically, the input values are normalized, so that they fall into the 0.0–1.0. Discrete-valued attributes can be re-encoded, so that the value of an input unit for each domain. For example, if property A has three possible values or known value {a0, a1, a2}, you can assign three input units, said A. That can be used I0, I1, I2 as input units. Each unit is initialized to 0 if A = a0, then I0 is set to 1; if A = a1, I1 set; it goes. Neural network can be used to classify (predict a given tuple of class labels) or predicted (predicted continuous value output). For classification, an output unit can be used to represent two classes (one class value of 1 represents a value of 0 represents another class). If more than two classes, each class with an output unit.

For the "best" hidden layer unit number, no clear rules. Network design is a process of trial and error, and may affect the accuracy of the results of the training network. The initial weight may also affect the accuracy of the results. Once the network is trained, and their accuracy can not accept, usually with different network topologies or use a different set of initial weights, repeat the training process. Accuracy can be estimated using cross-validation technique to help identify when to find an acceptable network.

157.3.3 Back Propagation

After the iterative process to disseminate the training data set tuples, each tuple of the same network prediction and the actual target value comparison. Target can be suppressed tuples training class label (for classification) or continuous values (for forecasts). For each training sample, modify the network weights between forecast and actual target value of the minimum mean square error. Such a change is "backward", i.e. from the output layer, through each hidden layer, to the first hidden layer (so called back propagation). Although not guaranteed, in general, the weight will eventually converge, the learning process stops.

(1) Initialize the weights: the weight of the network is initialized to the smallest random number (for example, from −1.0 to 1.0, or from −0.5 to 0.5). Each unit has an associated bias (bias), bias is also similar to the random initialization of the minimum number.

Each training tuple X by the following steps to deal with.

(2) Forward propagation input: First, the training tuples available to network input layer. Input through the input unit, does not change. In other words, the input unit j, Oj its output is equal to its input value Ij. Then, calculate the hidden layer and output layer, each unit actually input and output. Hidden layer or output layer units actually entered with the input of a linear combination of the calculation. To help explain this, the following figure shows a hidden layer or output layer unit. In fact, there are many inputs per unit, is connected to its upper layer of each unit of output. Each connection has a weight. To calculate the net input of the unit, connect the unit corresponding to each input is multiplied by its weight, then summed. Given the hidden layer or output layer unit j, the net input to unit j is Ij (Fig. 157.2).

A hidden or output unit j: unit j on input from the output layer. These multiplied with corresponding weights, weight and form. Weighted and combined to a unit j associated with the bias on. A nonlinear activation function for the net input (for ease of explanation, the input unit j is marked as y1, y2, …, yn. If unit j in the first hidden layer, the inputs correspond to the input tuple (x1, x2, …, xn)).

$$l_j = \sum_i WijOi + \theta j \tag{157.1}$$

which, Wij is the level of unit i to unit j, the connection weights; Oi is the output level of unit i; and θj unit j is the bias. Bias as the threshold used to change the unit of activity.

Hidden layer and output layer whichever is the net input to each unit, and then act on its activation function, as shown above. Unit with the performance of the

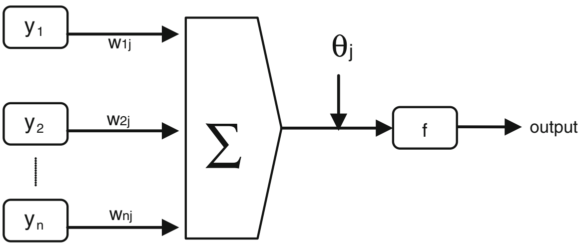


Fig. 157.2 Forward propagation input

function is represented by the symbol neuron activity. To logistic (logistic) orS-shaped (sigmoid) function. Given the net input unit j Ij, Oj is the output of unit j using the following formula:

$$o_j = \frac{1}{1 + e^{-Ij}} \tag{157.2}$$

This function is also known as extrusion function (squashing function), because it maps a large input range to a smaller range of 0–1. Logistic function is nonlinear and differentiable, making the back propagation algorithm for nonlinear separable classification modeling.

For each hidden layer, until the last hidden layer, calculate the output value of Oj, given the network prediction. In practice, due to the backward error propagation will also be required of these intermediate output values stored in the middle of each unit output value is a good way. This technique can significantly reduce the amount of computation required.

(3) The error back propagation: reflection by updating the network weights and bias prediction error, the error back propagation. For the output layer unit j, the error Errj calculated using the formula:

$$\mathrm{Errj} = \mathrm{Oj}(1 - \mathrm{Oj})(\mathrm{Tj} - \mathrm{Oj}) \tag{157.3}$$

which, Oj is the actual output unit j, and Tj is the j given training tuples given the known target. Note, Oj (1 − Oj) is the logistic function derivative.

To calculate the error of hidden layer unit j, consider the next level in the unit is connected to j and the error weighting. Error of hidden layer unit j is

$$\mathrm{Errj} = \mathrm{Oj}\ (1 - \mathrm{Oj}) \sum_k Errkwjk \tag{157.4}$$

which, Wjk by the next higher level unit k to unit j in the connection weights, and Errk unit k is the error?

Updates weight and bias, to reflect the spread of errors. Weighted by (5) update, which, ΔWijWij is the right change.

$$\Delta\mathrm{Wij} = \mathrm{ErrjOi} \tag{157.5}$$

$$\mathrm{Wij} = \mathrm{Wij} + \Delta\mathrm{Wij} \tag{157.6}$$

Variable l is the learning rate, usually between 0.0 and 1.0 take constant values. Back propagation learns to use the gradient descent search a collection of weights. These weights fit the training data, the network class prediction with the known tuple-mean-square distance between the target minimum. Learning rate to help avoid falling into the decision space of local minima (i.e., weight appears to converge, Tam is not the optimal solution), and help to find the global minimum. If the learning rate is too small, learning will be very slow. If the learning rate is too large, may appear between the swing in the wrong solution. But in reality, sucked the learning rate is set to 1/t, t is the current training set the number of iterations.

Update Bias by the following. Which, $\Delta\theta j$ change is biased θj

$$\Delta\theta j = (l)Errj \tag{157.7}$$

$$\theta j = \theta j + \Delta\theta j \tag{157.8}$$

Note that here we deal with each tuple to update weights and biases, which is called an instance update. Weight and bias increments can be accumulated to a variable, you can focus on training in all processed tuples updated after the weight and bias. The latter strategy is called periodic updates, scanning of the training set iteration is a cycle. In theory, the mathematical derivation of back propagation with periodic updates, and update instances of the practice is more common, because it usually produces more accurate results.

Termination conditions: training to stop, if

λ all of the previous cycle of ΔWij are less than a specified threshold, or

λ the previous cycle tuple classification error percentage is less than a threshold, or

λ exceed pre-specified number of cycles.

Computational efficiency depends on the time spent training the network. Given |D| tuples and w a weight, each cycle requires O (|D| $\times$ w) time. However, in the worst case may be entered next week's installments of the index number n. In practice, the time required for network convergence is very uncertain.

157.3.4 Neural Network Design

Customs relating to non-traditional security risks illegal smuggling and intellectual property protection the final results of the analysis can be divided into two types: no illegal smuggling, smuggling any irregularities. The nature of these two analytical results are completely different, if the customs clearance in advance according to the basic data to determine whether the goods contain a risk, and risk level, then you can focus on dealing with high risk goods, their increased inspection efforts, and for no risk or low risk rating procedures of customs clearance of goods to take a simple approach with appropriate checks, which can greatly improve the efficiency of Customs, the rational allocation of officers.

Currently Customs is to determine the risk of information after some investigation, according to the survey results and the results of the trial, and finally determined. If only the general level of risk or no risk information, the Department is no need to put so many resources to deal with. To conserve resources, we can data mining technology, customs clearance of goods based on the basic properties, combined with the Customs database record information, the risk of the goods to make a simple analysis, so that you can follow-up management of the customs of help.

This chapter selected 2006–2010 and 2010, Shanghai Customs Xuzhou some import and export customs clearance data as a research sample, the sample in the appendix. Constrained by data availability, this paper only selected one representative of 82 samples. One of the 62 samples used for model training, 20 samples used for model testing.

In selecting indicators, the general cargo clearance business number, business name, corporate credit rating, import and export methods, trade, import and export cargo information (quantity, price, etc.), import and export country (region), the accompanying documents, etc. indicators; and irregularities have been found smuggling and infringement cases, with the risk indicators are illegal ways, illegal channels, select channel clearance, seized tools, case type, amount of money involved, the amount of tax evasion and so on. In this paper, selected indicators, first select the data more complete index, by reference to the relevant customs documents and ask Customs related personnel, tested and validated, and finally selected the five risk indicators as the model input variables.

Reference to the Customs the original database, including corporate names, import and export methods, illegal methods.

We see from the raw data, raw data are described in some text, attribute names and attribute values are not discrete, but some vague description, and there are some attributes of our purpose and focus of the classification is not much relationship, such as seized units. Establishment of data warehouse also requires preprocessing the raw data, so that it can be applied to specific algorithms.

Data cleaning process by filling out the value of vacant, smooth noisy data, identify, remove outliers, and resolve inconsistencies to “clean up” data, this data is done on the original treatment of the following aspects:

(1) is to change the text property value data for the neural network algorithm can accept numeric values, such as business risk level has five (AA, A, B, C, D), then we can carry out these five levels data transformation, with “0” AA class enterprise, “1” means Class A enterprise, “2” B enterprises, “3” means Class C business, “4” class D enterprises. This data becomes a neural network algorithm can identify the data.

(2) the original data in some of the properties and classification of the purpose and focus not so much to remove, such as the seized units, seized time

(3) the value of the hollow handle to the database, such as business risk level is divided into: AA, A, B, C, D five, but often appear in the database, individual irregularities, illegal smuggling can be classified as C personal class enterprise.

Neural network is built on samples of the aforementioned research methods training and testing procedures. Parameter values used to set the input layer of five hidden layer unit number 20, the output layer is 2. Training function TRAINGD, training times for the 1000 training accuracy is 0.1, learning rate of 0.05. Training function uses an adaptive learning rate algorithm.

Output variables are divided into not found infringement and found infringing, respectively [10] and [01].

Verify the actual output of neural network, we found that the results of fitting accuracy rate of 85 %, can be used to assist non-traditional security risk management. At the same time we also found that model accuracy is relatively low, indicating that the model may be further optimized, it is because the data established a rough indicator, and because of the size of the model input variables and data availability, many of the risks factors not considered in the model, thereby causing the input value and the actual value is not very consistent. After this work needs to be further strengthened and improved to make the model more accurate.

157.4 Conclusions

Start from the concept of data mining and the existence of the non-traditional security risk information, risk analysis proposed neural network model has been proposed. According to relevant rules of texting the customs import and export information into a standardized discrete data, discrete data according to established three-layer artificial neural network model, and of the Customs Non-traditional security risk rating, and finally to validate the model through the empirical validity of. The model further support the establishment of effective risk management mechanism of science, scientific management and the efficient allocation of resources, improve the efficiency of customs officers, customs officers work to reduce the blindness and randomness, to provide effective decision support tools. Artificial neural network technology as an important means of developing intelligent, research-based data mining customs of non-traditional security risk analysis is of great significance.

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Chapter 158
Analysis of Transaction between Famers and Agents in Agricultural Market

Yuan-yuan Yu and Li-wei Bao

Abstract The transaction between farmers and agents is in the upstream of the agricultural supply chain. In the current economic environment, farmers have limited understanding of agricultural market trend, while agents can control marketing information correctly and roundly. Given the supply–demand relationship, trading between farmers and agents exists in many cases. This paper takes the price of wholesale market in producing area for reference, and analyses the trade in the fields between farmers and agents. It is concluded that information asymmetries benefit the agents in the aspect of transaction price.

Keywords Agent · Agricultural market · Farmer · Transaction analysis

158.1 Introduction

Agricultural products are different from industrial products, for example, different agricultural products have different planting area, growth cycle, picking time, storage condition and packaging requirements (Guo 2007). Those properties yield different circulation channels and transaction styles.

The transaction between farmers and agents is in the upstream of the agricultural supply chain (Li and Fu 2009). The fact that transaction subjects who are mainly farmers are scattered over the nation, and information asymmetries, various transaction locations, time, environment and mentality give rise to the different

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results including whether closing a deal and the final price, which means different "transaction scene" leading to different trading results. Urbanization is speeding up throughout China, while many rural areas still cannot put an end to backwardness. A substantial portion of farmers work on the farm all day long and they are ignorant of what is happening outside. Contrary to those farmers, agents are sensitive to the changes of agricultural markets, especially the fluctuation of trading price. Asymmetric information makes the trading results different (Lee et al. 2000; Gavirneni et al. 1999; Cachon and Fisher 2000). Many researchers employ game theory (John and Nash Jr 1950; Nash 1951) to analyze the transaction in agricultural market (Liu 2010; Tang and Chen 2011; Wang 2006; Ming and Sun 2010; Yin 2011; Yan and Zhan 2005; Tu and Leng 2010; Peng 2012). In the immediately following sections we shall apply static game model with incomplete information to analyze the trading results in the fields between farmers and agents who are players in this game theory.

158.2 Hypotheses

In general terms, we idealize the transaction by assuming that there are two players, a farmer and an agent. For convenience we introduce the substitution F and A respectively to stand for farmer and agent. One of the fundamental assumptions in the study of economy has been that players are highly rational, that each can accurately compare his desires for various things. The equilibrium point is the determination of the final transaction price, or, rather, a determination of how much it should be worth to each of them to engage in this deal. Moreover, we hold the view that if they cannot make a deal or F produces any remaining products, F will take the price of wholesale market in producing area for reference and sell the products in the wholesale market. In this situation, the profit of A is zero.

158.3 Variables

In the trade between F and A, the most important is to determine the transaction price and costs. We intended to illustrate the meanings of the variables we defined.

P1: the final transaction price after bargaining between F and A.

P2: purchasing price in wholesale market or A's selling price.

C1: per unit production costs including land costs, labor costs, intermediate inputs (seeds, chemical, fertilizer or pesticide) and so on.

C2: per unit logistics costs including loading and unloading costs, packaging and processing costs, storage costs and so on.

C: the fixed costs from field to wholesale market which will be paid by transporter.

Q1: the amount of agricultural products F planted.
Q2: the amount of agricultural products A will purchase.
R1: revenue of F.
R2: revenue of A.

158.4 Analysis

In order to explain the real situation we abstract from the "transaction scene" to form a mathematical model. There are four cases which we will illustrate in proper sequence.

158.4.1 Symmetric Information and Supply over Demand, that is Q1 > Q2

We have assumed that if the two players cannot make a deal or F produces any remaining products, F will take the price of wholesale market in producing area for reference and sell the products in the wholesale market. We write $R1 = Q2(P1 - C1) + (Q1 - Q2)(P2 - C1 - C2) - C$ to represent the revenue of F when F and A make a deal. However, $R1 = Q1(P2 - C1 - C2) - C$ represents the revenue of F when a deal doesn't be reached. A's corresponding revenue is $R2 = Q2(P2 - P1 - C2) - C$ and $R2 = 0$.

It is obvious that F prefers to make a deal with A if $Q2(P1 - C1) + (Q1 - Q2)(P2 - C1 - C2) - C \geq Q1(P2 - C1 - C2) - C$ is satisfied. Therefore, we have $P1 \geq P2 - C2$.

Similarly, for A, the requirement to deal with F is $Q2(P2 - P1 - C2) - C \geq 0$. Then we know that $P1 \leq P2 - C2 - C/Q2$.

When the information is symmetric and supply exceeds demand, F knows that A will decide the price according to $P1 \leq P2 - C2 - C/Q2$. As a corollary we may conclude that A must think that F will decide whether to close a deal with him according to $P1 \geq P2 - C2$. F hopes the price is no less than $P2 - C2$, and A regards $P2 - C2 - C/Q2$ as a ceiling price. It is clear that $P2 - C2 > P2 - C2 - C/Q2$, provided $C > 0$, so that they cannot reach an agreement.

158.4.2 Symmetric Information and Demand over Supply, that is Q1 < Q2

In this case, F will sell all the agricultural products to A once they strike a bargain.

The revenue of F is $R1 = Q1(P1 - C1)$ when the deal is done, and $R1 = Q1(P2 - C1 - C2) - C$ while not done. We think that F is likely to deal with A if $Q1(P1 - C1) \geq Q1(P2 - C1 - C2) - C$, which means $P1 \geq P2 - C2 - C/Q1$. The condition for A is the same as situation A. F knows what A is considering and A knows what F is thinking about, so the equilibrium point exists when $P1 = P2 - C2 - C/Q1$. Both sides' revenue are $R1 = Q1(P2 - C2 - C1 - C/Q1)$ and $R2 = 0$ respectively.

In reality, the equilibrium is non-existent. There are three reasons to explain it. One reason is that $R2 = 0$ is not A's expectation who definitely is a profitable individual, and it is not enough to meet the basic physiological needs. The second lies in that symmetric information is hard to realize in reality. The last is that the model is very simple and the analysis of a more realistic model should be an interesting affair.

158.4.3 Asymmetric Information and Supply over Demand, that is Q1 > Q2

Urbanization is speeding up throughout China, while many farmers in rural areas still cannot rid themselves of backwardness. A substantial portion of farmers work on the farm all day long and they are unaware of what is happening outside. Or construction of public infrastructure is poor in rural areas so that it's costly for farmers to access information. Contrary to those farmers, agents are sensitive to the changes of agricultural markets, especially the fluctuation of trading price.

Let P2H and P2L be high price and low price in the wholesale market. F has no idea the real price and A knows it exactly. However, F knows the probability for high price is μ, and $1 - \mu$ stands for probability of low price, provided $P2H > P2L$. We may also regard the real price as private information for A.

It is quite clear for F that supply exceeds demand at present. Nevertheless, F agrees a deal on the basis of prospective payoff. So the prospective payoff is $R1 = Q2(P1 - C1) + (Q1 - Q2)((\mu P2H + (1 - \mu)P2L) - C1 - C2) - C$, and $R1 = Q1((\mu P2H + (1 - \mu)P2L) - C1 - C2) - C$ is the payoff of a failing trade.

Transaction price shall conform to the following condition if F is glad to deal with A: $Q2(P1 - C1) + (Q1 - Q2)((\mu P2H + (1 - \mu)P2L) - C1 - C2) - C \geq Q1((\mu P2H + (1 - \mu)P2L) - C1 - C2) - C$. We obtain $P1 \geq \mu P2H + (1 - \mu)P2L - C2$. For A, when the real price is high, A expects $P1 \leq P2H - C2 - C/Q2$, and when price is low, A expects $P1 \leq P2L - C2 - C/Q2$.

When the purchasing price is high, $\mu P2H + (1 - \mu)P2L - C2 \leq P2H - C2 - C/Q2$ is required if the two players are willing to reach agreement. So we have $\mu \leq 1 - C/((Q2(P2H - P2L)))$. The final trading price is between $\mu P2H + (1 - \mu)P2L - C2$ and $P2H - C2 - C/Q2$. The exact figure is heavily depending on bargaining power of F and A. The maximum expectation disparity is

$(P2H - C2 - C/Q2) - (\mu P2H + (1-\mu)P2L - C2) = (1-\mu)(P2H - P2L) - C/Q2$, which implies that it's easier to bargain when the difference between P2H and P2L is small. Or we may conclude that smaller the difference, smaller fluctuations, easier to close a deal.

In contrast, when the purchasing price is low, $\mu P2H + (1-\mu)P2L - C2 \le P2L - C2 - C/Q2$ can never be true, for $\mu(P2H - P2L) \le -C/Q2$ is false (we cannot ignore the fact of $P2H > P2L$ and $\mu > 0$).

158.4.4 Asymmetric Information and Demand over Supply, that is Q1 < Q2

F still doesn't know the real price but the probability. The final trading price is determined by anticipation. We use $R1 = Q1(P1 - C1)$ to express F's revenue when it's done, while $R1 = Q1((\mu P2H + (1-\mu)P2L) - C1 - C2) - C$ to express revenue when it's not. So $Q1(P1 - C1) \ge Q1((\mu P2H + (1-\mu)P2L) - C1 - C2) - C$ or $P1 \ge \mu P2H + (1-\mu)P2L - C2 - C/Q1$ is desirable. Just like situation C, $P1 \le P2H - C2 - C/Q2$ and $P2L - C2 - C/Q2$ must be satisfied.

If price is high, $\mu P2H + (1-\mu)P2L - C2 - C/Q1 \le P2H - C2 - C/Q1$ can hold water for $P2H > P2L$ is obvious. Since A knows F doesn't know the environment of market, A offers $\mu P2H + (1-\mu)P2L - C2 - C/Q1$ on his own terms. Although F has no idea of market quotation, F knows the probability of high and low. F may respond to A's offer as $\mu P2H + (1-\mu)P2L - C2 - C/Q1$ in the bargaining in terms of A's anticipation. In the end, equilibrium maintained when transaction price reaches $\mu P2H + (1-\mu)P2L - C2 - C/Q1$. At this point, we write $Q1(\mu P2H + (1-\mu)P2L - C2 - C/Q1 - C1)$ to represent F's revenue and $Q1(1-\mu)(P2H - P2L) > 0$ to refer to A's. We now show that asymmetric information is in favor of A from analysis above.

If the price is low, the situation is more or less like situation C. That is, $\mu P2H + (1-\mu)P2L - C2 - C/Q2 \le P2L - C2 - C/Q2$ does not hold.

158.5 Conclusions

We employ game theory to analyze the transaction between famers and agents. The model is simple even though we make attempt to come closer to reality. However, we still come to some conclusions. When information is asymmetric, demand exceeds supply and real price is high, both sides can make a deal at price $\mu P2H + (1-\mu)P2L - C2 - C/Q1$. While the deal can be secured once asymmetric information, supply exceeding demand and high price are satisfied at the same time. The ultimate trading price may not be determined until after tough bargaining.

In order to make the transaction smooth in the agricultural markets, government should standardize market order, promote fair competition, and set up corresponding operation rules with expectation of reducing wide price fluctuation. In the end, agricultural markets can offer higher transparency and reduce transaction cost.

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Chapter 159
The Operation Data Analysis Research Based on the Queuing Theory of the D Cigarette Factory Product Warehouse System

Xiao-he Sheng, Wei-ping Yang, Tian-min Liao, Yao Liang, Wen-xia Xu and Xing-zhao Yi

Abstract Queuing theory is a regularity discipline based on the influence of random factors which fostering the phenomenon of queuing in line or congestion of the system (Meng 1998). After a deep research on the basic ideology of queuing theory, this paper establishes the automated warehouse mathematic model of the system and has given the flabby condition constraints of the warehouse model with its application. According to this model, people can work out the parameters such as equipment utilization efficiency of automatic warehouse system, the number of goods waiting for service, the average waiting time and the average captain operation in system, etc. Finally with the system analysis, the paper provides the basis for optimization design or evaluation of the status of the warehouse system.

Keywords Keywords · Queuing theory · Automated warehouse · Mathematical modeling · Cigarette factory warehouse system

159.1 Introduction

With the increasing progress of globalization of economy and the rapid development of science and technology, the modern logistics has been paid more and more attention. It is also regarded as the "third profits source" except the function

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of reducing consumption of resources and improving labor productivity (Wu and Xiao 2001). As the typical representative in the modern logistics field, with a higher demand of automation degree, automated warehouse has been extensively used and has achieved significant results (Gen and Cheng 1996). It reduces the tobacco logistics costs greatly and so to obviously improve the circulation of tobacco production efficiency (Yin and Qi).

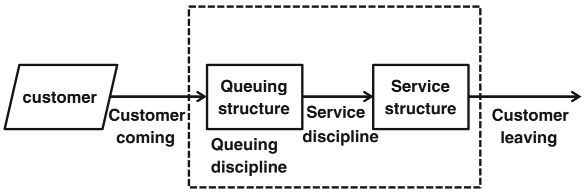
159.2 The Queuing Theory

Queuing theory is said to be a theory of stochastic service system, which is to study a discipline of regularity, a phenomenon of queuing in line or congestion because of random factors' influence (Dong et al. 2010). The longer the line up, the more time to waste, at the meanwhile, the lower efficiency of system, shown as Fig. 159.1. With the fast growth of Queuing Theory, logistics systems has been widely used in wide fields, such as medical treatment process system, transportation, distribution, supermarket cashier, AGV dolly, and have made remarkable effect. But in the automatic warehouse system, the application is still relatively rare. With a in-depth research of a cigarette factory product warehouse system, basing on the basis of Queuing Theory, the author designs a scheme of the model mathematically, and works out the operation of the system parameters, so to optimize and improve the system.

159.3 Queuing Model of Automated Warehouse

Automated warehouse refers to a storage system that to save goods by top shelves, and put in or outbound goods with roadway stacker automatically (Zhou 2002). The product warehouse system in a cigarette factory mainly includes finishing warehousing subsystem, empty tray group supply subsystem, finished product outbound subsystem, empty tray group return library subsystem, exception handling and checking subsystem and scattered dish smoke process subsystem, etc. (Sun et al. 2004).

Fig. 159 1 Queuing system block diagram



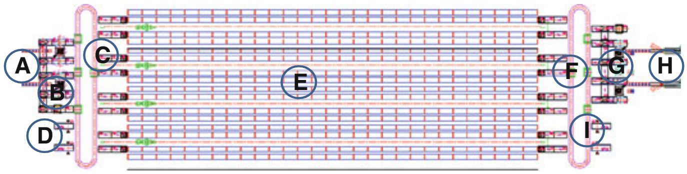


Fig. 159 .2 The basic composition of cigarette factory products warehouse system

159.3.1 Overview of D Cigarette Factory Products Warehouse System

The basic composition of cigarette factory products warehouse system as Fig. 159.2:

Description of working process as follows:

(I) Warehousing System
Finished products ars transported from upstream, via the link smoke transmission system and are passed to Treasury product warehouse platform, waiting in A place and cached by B palletizing robot (according to A smoke every tray 28). The procedure includes empty tray group (each group of 10), passing the C conveying system (including ring shuttle car and chain, roller conveyor, etc.), then to be completed by stacker Treasury (Heungson and Samantha 1997).

(II) Storage System
The whole finished products tray and empty smoke tray group are saved in E place, including sampling inspection, returning-back process of unqualified outbound products during the period (van den Berg and Zijm 1999).

(III) Outbound System
The whole tray products are sent to the platform in F by stacker smoke, transported by conveying system (including ring shuttle car and chain, roller conveyor, etc.) to G place, after being removed by robots, finally to finish the outbound homework by artificial with telescopic chain conveyors (Hai and Di 2005).

159.3.2 The establishment of product warehouse queuing model

(I) The establishment of the constraints and relaxation conditions of warehouse model

(i) The warehouse is limited to unit format automated warehouse;
(ii) Shelves for closed roadway shelves, only four sets of roadway in a stacker, there are four service windows within the system, accessing to goods service:

(iii) The arrival time of the goods obeys to random position distribution (Ma and Jiang 2008), for product warehouse stackers service, the time depends on distribution (Xu and Liu 2009), and when all warehouse locations are parked, the following goods will be in a waiting state;
(iv) The whole warehouse is one end income, and the other output;
(v) There is no waiting loss in the system.

(II) The establishment of warehouse queuing model
It is known from the constraint and relaxation conditions that the warehouse system obeys to the Multiple Service Windows Waiting System M/M/n queuing model (Hua 1987). Suppose the system has n service windows, each window operate independently; the finished products arrives according to Poisson flow, the strength for λ; The service time of every window tends to distribution, then average service rate for μ; the stable distribution of theory proving system is $\rho = \frac{\lambda}{n\mu} < 1$, $\rho_1 = \frac{\lambda}{\mu}$. The model is shown as Fig. 159.3:
Refer to the Queuing M/M/n Model calculation method, several computation formulas of related parameters is as follows (Gan and Zhou):

(i) The probability of 0 service desk in system:

$$P_0 = \left(\sum_{k=0}^{n-1} \frac{\rho_1^k}{k!} + \frac{\rho_1^n}{n!} \frac{1}{1-\rho} \right)^{-1}$$

(ii) Since there is no waiting loss existing, the relative through ability of the system: Q = 1;
(iii) The absolute through capability of system:

$$A = \lambda Q = \lambda$$

(iv) The average length of waiting queue:

$$L_q = \frac{\rho_1^{n+1}}{(n-1)!(n-\rho_1)^2} p_0$$

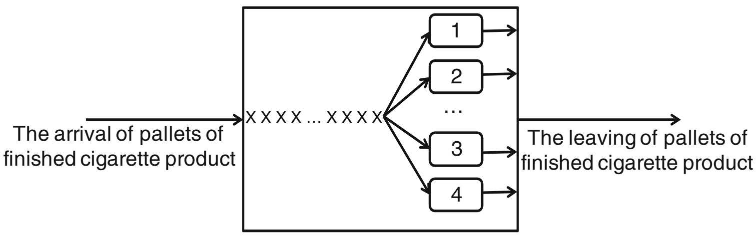


Fig. 159.3 Multiple service windows waiting system M/M/n queuing model

(v) Average number of windows in service: $L_P = n\rho\left[\sum_{k=1}^{n} \frac{(n\rho)^{k-1}}{(k-1)!} p_0 + \sum_{k=n+1}^{\infty} \frac{n^n \rho^{k-1}}{n!} p_0\right] = n\rho = \rho_1$

(vi) The line length in system:

$$L_s = L_q + L_P = \frac{\rho_1^{n+1}}{(n-1)!(n-\rho_1)^2} p_0 + \rho_1$$

(vii) The average waiting time of goods:

$$W_q = \frac{L_q}{\lambda} = \frac{\rho_1^n p_0}{\mu n \bullet n!(1-\rho)^2}$$

(viii) The probability of time-waiting of goods in system:

$$C(n, \rho_1) = \sum_{k=n}^{\infty} p_k = \sum_{k=n}^{\infty} \frac{n^n}{n!} \rho^k p_0 = \frac{np_n}{n - \rho_1}$$

159.4 The Calculation and Analyzation of Relative Parameters of D Cigarette Factory Product Warehouse System

159.4.1 The Calculation of Related Parameters in the System

D cigarette factory is a plant which has a production capacity of 446000 big box of cigarettes, on the basis of each tray with 28 smoke cold salvers, working 250 days a year, 7 hours a day, the loading and unloading keep balance. Then the calculation is as below:

446000 boxes/year by 5 ÷ 250 days ÷ 28 a/tray ÷ 7 = 46 PL/h;

According to the peak of 1.3, the storage capacity is: 46 PL/h x 1.3 = 60 PL/h

According to each group is 10 trays, the flow of empty tray group is: 60 PL/h ÷ 10/group = 6 group/h. Suppose the loading and unloading is balanced in this system, the outbound traffic is: 60 PL/h + 6 group/h = 66 PL/h. The total flow of the system is: 66PL/h × 2 = 132PL/h. That is: $\lambda = 132$PL/h

The capacity of single stacker is 67PL/h, since in the actual operation, stacker operational efficiency cannot be higher 85 % than its real ability, so we set = 67 x 85 % = 57 PL/h; then can come:

$$\rho_1 = \frac{\lambda}{\mu} = \frac{132}{57} = 2.3 \quad \rho = \frac{\lambda}{\mathrm{n}\mu} = \frac{132}{4 \times 57} = 0.58 < 1$$

So the queuing system is stable. With the actual date into the above formula, the numeral value of other parameters can be calculated as follows:

(i) The probability of 0 service desk in system:

$$P_0 = \left(\sum_{k=0}^{4-1} \frac{\rho_1^k}{k!} + \frac{\rho_1^4}{4!} \frac{1}{1-0.58} \right)^{-1} = 0.103$$

(ii) The relative through ability of the system: Q = 1

(iii) The absolute through capability of system:

$$A = \lambda = 132$$

(iv) The average length of waiting queue:

$$L_q = \frac{\rho_1^{n+1}}{(n-1)!(n-\rho_1)^2} p_0 = \frac{2.3^5}{3!(4-2.3)^2} \times 0.103 = 0.382$$

(v) Average number of windows in service:

$$L_P = n\rho = \rho_1 = 2.3$$

(vi) The line length in system:

$$L_s = L_q + L_P = 0.382 + 2.3 = 2.682$$

(vii) The average waiting time of goods:

$$W_q = \frac{L_q}{\lambda} = \frac{0.382}{132} = 0.0029h = 0.174\text{min}$$

(viii) The probability of time-waiting of goods in system:

$$C(n, \rho_1) = \frac{np_n}{n-\rho_1} = \frac{4 \times 0.124}{4-2.3} = 0.293$$

(ix) Efficiency of stacking machine operation:

$$\theta = \frac{L_p}{n} = \frac{2.3}{4} = 0.575$$

159.4.2 System Analysis Results

After systematically analysis, we can find that the queuing model is relatively stable. With satisfaction of the balance between loading and unloading, it has the shorter waiting time of goods, and belongs to be a reasonable and fluent automatic system. So it is quite fit the operation status of D cigarette factory warehouse system. Though the model is excellent, it also has some shortages. There are only

2–3 stackers in work on average, it is not high of the equipment efficiency, existing resources wasting problem. Faced with this condition, we can consider to increase the capacity of the storage and improve production efficiency by increasing the subsequent equipments (Yang and Liao 2000).

159.5 Conclusion

Based on the systematically analysis of the D cigarette factory warehouse system, combining with the queuing relating theory, this paper has made a calculation and consideration to the product warehouse system parameters. So to provide accurate data support for optimization design and system evaluation. The author aims to discover the deficiency in time and adjust design or manufacturing strategy. Finally the paper would have great influences of automatic warehouse system on the design, optimization, plan evaluation and strategy adjustments positively.

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Chapter 160
Drop-Shipping in Retailer-Oriented Dual-Channel Supply Chain Based on Customer Channel Preferences

Shan Yu and Ming-rong Deng

Abstract Nowadays, drop-shipping plays an important role in e-commerce. With the growing popularity of online shopping, traditional retail enterprises have established online stores, to expand sales and compete with online retailers. Under the circumstances, the paper studies whether retailer can make profits using drop-shipping in dual-channel supply chain based on customer channel preferences. Make some contributions to traditional retail enterprises better using drop-shipping in online sales.

Keywords Drop-shipping · Dual-channel supply chain · Channel preferences · Channel selection

160.1 Introduction

The drop-shipping is applied to online sales with the development of e-commerce. Retailers receive online orders, then suppliers who saves the products directly send them to consumers according to retailers' orders. The emergence of e-commerce greatly reduces information exchange cost between suppliers and retailers in drop-shipping.

Drop-shipping has some advantages compared with the traditional model which retailers hold inventory. Retailers can reduce inventory costs, transportation costs and under-stock cost, while suppliers can increase sales, reduce advertising and other marketing costs. It is very popular in the online sales because of these advantages. According to the survey, 30.6 % of online retailers use the drop-shipping as their primary way to fulfill order, while 44.5 % as an alternative way

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(Rabinovich 2005). Spun.com Corporation (CD retailer) avoided $8 million in inventory investment using drop-shipping. Amazon.com, through the drop-shipping channel, sells mobile phones, computers and unpopular books (Netessine and Rudi 2001).

It is clear that drop-shipping has played an important role in e-commerce. With the growing popularity of online shopping, large traditional retail enterprises, such as Suning, Gome, Intime, have set up online store, to expand sales and compete with online retailers. Under the background of traditional retailers opening up online store, the paper establishes dual-channel supply chain including traditional channel and online channel, studying whether the retailer can make profits using drop-shipping. Hope to make some contributions to traditional retailers better using drop-shipping in online sales.

160.2 Literature Review

Drop-shipping is first proposed in the marketing field which focuses on qualitative analysis. Quantitative analysis mainly concerns three aspects—channel selection strategy, inventory strategy and supply chain coordination.

In inventory strategy, Khouja (2001) proposed the mixed inventory model of the retailer, which the retailer holds inventory and use drop-shipping at the same time, to circumvent the shortcomings of drop-shipping, such as higher transportation costs and longer delivery time. Lee and Chu (2005) pointed out that the retailer pushing the risk of inventory to supplier does not necessarily increase its profits as well as decrease the profits of suppliers. Bailey and Rabinovich (2005) find that when the retailer's market share rises, retailers should use both the traditional and drop-shipping channel. When the products' popularity is high, the retailer should be more dependent on traditional channel. Ayanso et al (2006) use Monte Carlo simulation model to study the optimal inventory rationing strategies for retailers using drop-shipping. Khouja and Stylianou (2009) studied the impact of drop-shipping model on non-perishable inventory system, and proposed two (Q,R) inventory models that allow a retailer to use drop-shipping in case of a shortage during lead-time. Liu and Wang (2008) analyse threshold level inventory rationing policies when retailer uses its own inventory and drop-shipping to fulfill orders.

In the supply chain coordination, Netessine and Rudi (2001) proposed that the supplier pay for a part of retailers' marketing costs, while the retailer compensates for the surplus of supplier at the end of the season. Yao et al. (2008) study the profit sharing between retailer and supplier under drop-shipping model, and analyses the relationship between order fulfillment and profit sharing. They put forward countermeasures to improve the quality of order fulfillment. Gan et al. (2010) studied commitment-penalty contracts in drop-shipping supply chains coordination with asymmetric demand information. Thus, the supplier can obtain the retailer's demand information, and maximize the expected profit. Li et al.

(2006) analyzed drop-shipping supply chain coordination with one supplier and multiple retailers, and discuss existence and uniqueness of Nash equilibrium.

In channel selection, Netessine and Rudi (2001) found that the structure of the supply chain power influences inventory decision-making and supply chain profit. They point out both channel members prefer drop-shipping agreements over the traditional agreements for a wide range of problem parameters. Netessine and Rudi (2006) analyses the channel selection with one distributor and multiple retailers. Through modeling and analysis, they obtained optimal channel selection policy in a certain range of parameters, including demand uncertainty, the number of retailers, wholesale prices and transportation costs. In addition, they improve the supply chain system using dual strategy, which combines drop-shipping with the traditional model. In detail, the traditional model is regarded as the main method to fulfill order, while drop-shipping as a backup.

However, all these studies are based on a single channel or dual-channels with identical demand distribution assumptions. However, Kacen et al. (2002) analyses the customer preferences between the traditional and online stores, and propose the customers have channel preferences. Chiang and Monahan (2005) studied the dual-channel supply chain inventory decisions based on different market demand in the traditional retail channels and direct sales channels. Xiao et al. (2009) study the optimal inventory policy and admission policy when retailer sells through its own physical and online stores, also sells through third-party websites by means of affiliate programs.

Under the background of traditional retailers developing online channels, the total customer demand splitting into two channels is more realistic. Therefore, we study the conditions of large retailers adopt drop-shipping based on this branch.

160.3 Analytical model

We model a supply chain with two echelons: one supplier and one dominant retailer. In traditional channel, the retailer holds inventory to meet the physical retail store market demand, while in online channel, the retailer use drop-shipping to sell goods.

Under the framework of newsvendor model, the retailer faces different customer in traditional and online channel. Customers of the two channels are not interchangeable, that is, customers have channel preferences. Some customers choose traditional channel due to its value-added services, while others choose online channel because of its convenience. If their needs can't be met, they may choose other alternatives in the same channel. In addition, the consumers online is more concerned about the trend of price, preferring to wait for discounts, which is different from customers in traditional stores (Su and Zhang 2008). Therefore, we assume that the two channels has different demand distribution function.

Based on the customer preference, retailer develops online channels will reduce the customer demand of the physical store. It is necessary to study whether the retailer can use network channel to make more profits.

Compared with traditional model which retailer holds inventory, this article studies the channel selection strategy of dominant retailer and supplier, analyzing the impacts of some parameters on channel selection, such as the demand preferences, wholesale prices, retail prices, production costs and other parameters.

160.3.1 Notations and Assumptions

The total customer demand is X. The probability distribution and density function of the demand is $F(\cdot)$ and $f(\cdot)$. The total customer demand is split into two channels. The traditional channel customer demand is X_1, distribution and density are $F_1(\cdot)$ and $f_1(\cdot)$. The online channel customer demand is X_2, distribution and density are $F_2(\cdot)$ and $f_2(\cdot)$. $X_1 = aX$, $X_2 = bX$, and $a + b = 1$.

In traditional model, the retailer orders q; In drop-shipping, in the traditional channel retailer orders q_1 with price w. In online channel, retailer orders quantity q_2 with price w'. A reasonable drop-shipping contract should contain a higher wholesale price than the traditional channel because the supplier will bear the transportation costs and inventory risk. In reality, w' is usually 10–20 % higher. The selling price is p, the supplier production cost is c, and the cost of understock and overstock are 0.

160.3.2 Traditional Model

In traditional model, retailer orders q at the beginning of selling season and holds inventory. π_{R0}, π_{S0}, π_{T0} are the profits of supplier, retailer and total supply chain. To simplify the problem, we assume X is uniform distribution in $[0, u]$. The distribution and density function are $F(x) = \frac{x}{u}$ and $f(x) = \frac{1}{u}$ for $x \in [0, u]$.

The optimal order quantity is q^*, where $q^* = u(\frac{p-w}{p})$. Thus, $\pi^*_{R0} = \frac{u(p-w)^2}{2p}$, $\pi^*_{S0} = \frac{u(w-c)(p-w)}{p}$, $\pi^*_{T0} = \frac{u(p-w)(p+w-2c)}{2p}$.

160.3.3 Drop-Shipping Model

Retailer use drop-shipping in online channel. Supplier determines their production, that is, the number of products for online sales.

$$F_1(x) = \frac{x}{au}, \quad f_1(x) = \frac{1}{au}$$

$$F_2(x) = \frac{x}{bu}, \quad F_2(x) = \frac{1}{bu}$$

Retailer first determines order quantity q_1 in traditional channel, then supplier determines production quantity q_s. Thus, production quantity online q_2, where $q_2 = q_s - q_1$.

The profits of retailer and supplier are π_{R1}, π_{S1}, where

$$\pi_{R1} == (p - w)q_1 - p\int_0^{q_1} F_1(x)dx + (p - w')\left(q_2 - \int_0^{q_2} F_2(x)dx\right)$$

$$\pi_{S1} = (w - c)q_1 + w'\left(q_2 - \int_0^{q_2} F_2(x)dx - cq_2\right)$$

The optimal order quantity in traditional and online channel is q_1^*, q_2^*, where

$$q_1^* = au\left(\frac{p - w}{p}\right), \quad q_2^* = bu\left(\frac{w' - c}{w'}\right)$$

$$\pi_{R1}^* = \frac{au(p - w)^2}{2p} + \frac{bu(p - w')(w'^2 - c^2)}{2w'^2}$$

$$\pi_{S1}^* = \frac{au(w - c)(p - w)}{p} + \frac{bu(w' - c)^2}{2w'}$$

$$\pi_{T1}^* = \frac{au(p - w)(p + w - 2c)}{2p} + \frac{bu(w' - c)[w'(p - c) + c(p - w')]}{2w'^2}$$

160.3.4 Conditions of Selecting Drop-Shipping Model

(1) Conditions of increasing retailer's profits

Define $\Delta_R = \pi_{R1}^* - \pi_{R0}^*$ as the payoff when retailer adopted drop-shipping, where

$$\Delta_R = \frac{bu\left[p(p - w')(w'^2 - c^2) - w'^2(p - w)^2\right]}{2pw'^2}$$

Proposition 1 *Retailer's expected profits will increase when adopting drop-shipping if* $p(p-w')(w'^2-c^2)-w'^2(p-w)^2>0$. *Especially when* $w'=w$, *the condition can be simplified as* $w^3>pc^2$.

(2) Conditions of increasing retailer's profits
Define $\Delta_S=\pi^*_{S1}-\pi^*_{S0}$ as the payoff when supplier adopted drop-shipping, where

$$\Delta_S=\frac{bu\left[p(w'-c)^2-2w'(w-c)(p-w)\right]}{2pw'}$$

Proposition 2 *Retailer's expected profits will increase when adopting drop-shipping if* $p(w'-c)^2-2w'(w-c)(p-w)>0$. *Especially when* $w'=w$, *the condition can be simplified as* $(w-c)(2w^2-pw-pc)>0$.

(3) Conditions of increasing both of their profits

Situation 1: Both of their profits increase. Under the circumstance, the two conditions $\pi^*_{R1}\geq\pi^*_{R0}$ and $\pi^*_{S1}\geq\pi^*_{S0}$ should be satisfied, i.e.:

$$\begin{cases} p(p-w')(w'^2-c^2)-w'^2(p-w)^2>0 \\ p(w'-c)^2-2w'(w-c)(p-w)>0 \end{cases} \tag{160.1}$$

Proposition 3 *If* $\pi^*_{S1}\geq\pi^*_{S0}$ *and* $\frac{2w(p-w')}{w'(w'-c)}\geq\frac{p-w}{w-c}$, $\pi^*_{R1}\geq\pi^*_{R0}$. *Especially when* $w'=w$, *if* $\pi^*_{S1}\geq\pi^*_{S0}$, $\pi^*_{R1}\geq\pi^*_{R0}$.

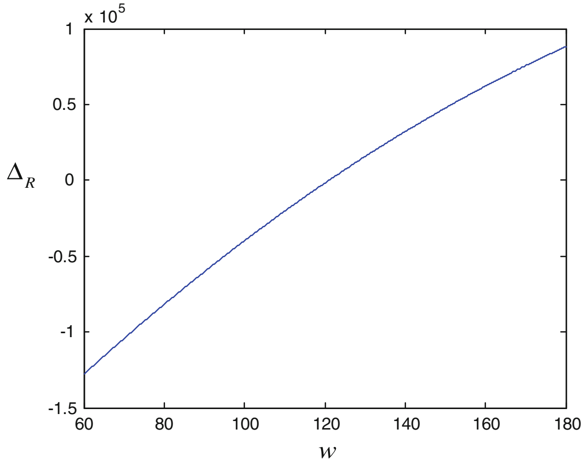
If $\pi^*_{R1}\geq\pi^*_{R0}$ and $\frac{w'(w'-c)}{w'+c}\geq 2(w-c)$, $\pi^*_{R1}\geq\pi^*_{R0}$.

Situation 2: Profit of total supply chain increases, and divides to both parts. Define $\Delta_T=\pi^*_{T1}-\pi^*_{T0}$ as the payoff of total supply chain when adopting drop-shipping, where

$$\Delta_T=\frac{bu(w'-c)[w'(p-c)+c(p-w')]}{2w'^2}-\frac{bu(p-w)(p+w-2c)}{2p}$$

Proposition 4 *The supply chain's expected profits will increase when adopting drop-shipping if* $\Delta_T\geq 0$. *Especially when* $w'=w$, *the condition can be simplified as* $w^3(w-2c)>pc^2(p-2w)$.

Fig. 160.1 Relationship between w and Δ_R



160.4 Example

Suppose $a = 0.3$, $b = 0.7$, $u = 10000$, $c = 30$,$w = 150$, $w' = 180$, $p = 300$.

The payoff of retailer adopting drop-shipping is Δ_R, where $\Delta_R = 62500$. For supplier, the payoff is Δ_S, where $\Delta_S = 7500$. Under this condition, both parties will prefer to adopt drop-shipping.

In addition, we can find the relationship between a, b, c, w, w' or p and Δ_R, Δ_S or Δ_T. For example, the relationship between w and Δ_R is given in Fig. 18.1.

Because of the limited space, we will not enumerate all the relationships of each other. Several conclusions will be given in Sect. 160.5.

160.5 Conclusions

Compared the drop-shipping model with traditional retailers hold inventory model, this paper have found the condition when supplier and retailer will choose drop-shipping in retailer dominant dual-channel supply chain. First of all, for the products with relatively high wholesale price and low production costs, retailers and suppliers are preferred drop-shipping. For suppliers, it assumes the risk of holding inventory, lower production decreases the risk. For retailers, higher wholesale price increase their risk of holding inventory, so they also prefer drop-shipping. Secondly, the proportion of demand preferences between the different channels does not affect the drop-shipping choice, but if the choice is made, the proportion has positive correlation to the profit. In addition, if the suppliers can use drop-shipping to increase profits, then the retailers will also make profits in a wide range of parameters. Hope that these findings can provide some guidance to retailers for channel selection strategy.

However, there are some limitations of the study. Firstly, based on the demand distribution of uniform distribution assumption, we don't get more general conclusions under other demand distribution. Secondly, the customers have channel preferences, but sometimes they will change for the products they want are out of stock. Thirdly, the studies of supply chain coordination in drop-shipping is not rich. Nowadays, drop-shipping has been widely used in practice. So it is very important and necessary to study drop-shipping in dual-channel supply chain.

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Chapter 161
Study on Quick Response Distribution Task Management in Agricultural Products Logistics Based on E-commerce

Chan-jun Zhang and Wei-hua Zhang

Abstract Distribution task management has great influence on improving quick response ability in Agricultural Products E-commerce Logistics (APEL). This paper put forward a collaboration task management model on quick response distribution in APEL, and explored the multifactor constraint framework of collaboration management based on lead time. At last, the participants selecting and its operation mechanisms on distribution task collaboration management were analyzed.

Keywords Quick response distribution · Collaboration task management · Agricultural products e-commerce

161.1 Introduction

Prior to the 1980s, the central problem in enterprise management is to handle partnerships with suppliers, and reduce cost and improve quality. But in today's fast changing market, the central task has become innovation, flexibility and speed (Magretta 1998). Modern APEL becomes more time stringent, the quick response task collaboration management of agricultural products distribution reflects the integrated competition ability of system about speed, flexibility and service and so on by taking time as the core. Distribution task often shows a large scale frequent mobile service, such as position dynamic mobile, environment complex and changeful, relative time pressing, task interdependence and multiparticipants

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(Cho et al. 2008). These characteristics make distribution task management face enormous challenges on response ability in time-based competition, which may affect the efficiency of agricultural products e-commerce and its competitiveness. Combined with quick response idea based on time-based competition in this paper, the distribution task management model on collaborative distribution chain was planned. It also measured the collaboration management flexibility and adaptability of distribution task through the time sensitivity marker.

161.2 Collaboration Model on Quick Response Distribution Task Management in APEL

In recent years, agricultural products e-commerce has demand more and more for logistics distribution. It not only requires the guarantee for quality, service, function and low cost in agricultural products distribution but also concerns more about flexibility and timeliness requirements. E-commerce can carry out dynamic management of inter-regional and cross-time demands (Blackburn 1991). But as a business and matter combination in the last logistics part, the distribution operation management efficiency and its cost become bottleneck in APEL development. Therefore, how to collaborative manage diverse, complex, pressing and many subjects' distribution task, and regulate its distribution business, then improve the distribution quick response ability become the urgent need of APEL.

161.2.1 Collaboration Management Model

The quick response distribution task collaborative management in APEL takes time management as the core. They make decision on distribution task allocation and location by time sensitivity marker that linking distribution lead time, distribution task calibration and its business driven framework. The collaboration management model of distribution task is mainly composed of five parts, as shown in Fig. 161.1.

(1) *Driving Framework of Distribution Business*
This module is the collaboration management center of distribution task, but also the interface of APEL platform. It docks distribution task (T_j) and demand (D_j) in e-commerce by the time sensitivity index (I_t). In accordance with the rules of business driven, it coordinates the information flow, material flow, capital flow and business flow from the external system. On the other hand, the scheduling window (W_j) of distribution task is excavated from the internal APEL platform. Business driven framework provides two driving ways, i.e. time driving and value driving. Thus, the quick response distribution task is divided into rigid response and flexible response. Among them, the rigid quick

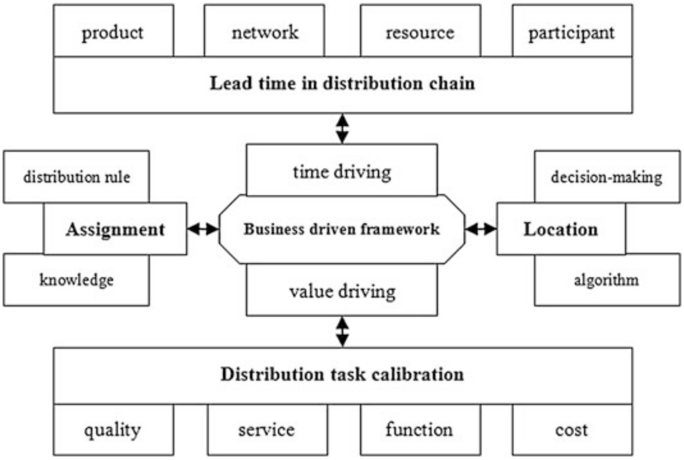

Fig. 161.1 Collaboration model on quick response distribution task management

response emphasizes absolute importance of time, such as quick response distribution of agricultural products emergency logistics system; the flexible quick response emphasizes value maximization. It takes time as center, such as most commercial logistics quick response system. So, it is an overall balance in service, function, quality, cost, etc.

(2) *Lead Time Management in Distribution Chain*

Lead time (L_i) management in distribution chain is the premise and basis of realizing quick response. This module considers mainly about the sameness and difference of distribution product (P), network (N), resources (R) and user (U). Firstly, it should build a hierarchical time tree or time diagram of the task time including three aspects as time quota, lead time and time window. And then lists hierarchical time index and influencing factors according to business process, business function, profit or value etc. Finally, eliminate the waiting time of distribution chain from system point by using the Analytic Hierarchy Process (AHP) and Delphi methods from both qualitative and quantitative aspects. According to compressing the plan time, operation time and reaction time of complain, it protects the consistent of lead time coordination and quick response ability with the sensitivity index in distribution task management.

(3) *Distribution Task Calibration*

This module delineates tags for every distribution task from four dimensions, i.e. quality (Q), service (S), function (F) and cost (C). The tags are the parameters that connecting with other modules. And then structures the matching features (T_j) of description task record about every distribution task, as shown in Fig. 161.2 (Table 161.1).

(4) *Distribution Task Assignment and Location*

These two modules define the basic rules and methods of task assignment and location searching, matching and reasoning respectively. The core is to match

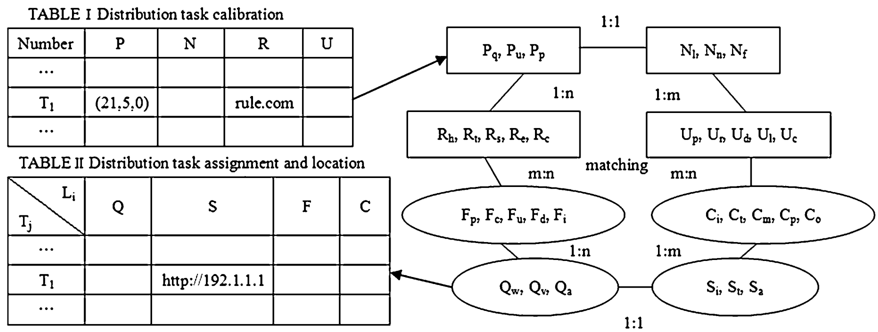

Fig. 161.2 Collaborative multifactor constraint framework of distribution task

lead time (L_{ik}) and task characteristics parameters (T_{jk}) of every distribution task in distribution chain according to creating business-driven function. And then call decision-making models and methods under the supporting of allocation rules and knowledge management shown as Fig. 161.2 (Table 161.2). Thus, the complete collaborative intelligent service system of quick response distribution task management based on agricultural products e-commerce is formed.

161.2.2 Multifactor Constraint Framework

The quick response distribution task management in APEL is a dynamic business cohesion and decision-making on the basis of interaction game between multiple factors. So, there are many reaction nodes, multi-constrains optimization and benefits contradiction problems. As shown in Fig. 161.2, lead time management and task-oriented distribution task calibration are mapped to related products, network resources and users as well as quality, service, function and cost respectively according to 1:1, 1:n and m:n three kinds of relationships. And then matches constraint rules dynamically on the basis of knowledge management, decision-making models and methods etc. The specific plan can be divided into two processes.

First, making the product, network, resource, user calibration for the located distribution task, and its related indicators are divided as follows:

product = {quality grade, quantity, package grade} = {P_q, P_u, P_p};

network = {distribution line, network node, business function} = {N_l, N_n, N_f};

resource = {human resources, transport resources, storage resources, handling equipment, circulation processing equipment} = {R_h, R_t, R_s, R_e, R_c};

user = {production enterprise, processing enterprise, distribution center, logistics enterprise, customer} = {U_p, U_r, U_d, U_l, U_c}.

On this basis, combined with the specific distribution task, carrying out the distribution task allocation and positioning according to quality, service, function and cost. The related indicators are divided as follows:

quality = {weight loss, volume loss, amount loss} = {Q_w, Q_v, Q_a};

service = {information management, tracking services, after sale service} = {S_i, S_t, S_a};

function = {packaging, circulation processing, unit loading, distribution, information processing} = {F_p, F_c, F_u, F_d, F_i};

cost = {inventory cost, transportation cost, management cost, information processing cost, outsourcing cost} = {C_i, C_t, C_m, C_p, C_o}.

161.3 The Task Management Mechanisms of Quick Response Distribution in APEL

In modern e-commerce, the customers' requirements for agricultural products distribution become personalized, diversified and high value increasingly, but their loyalty has declined (Choi et al. 2006). Quick response distribution task management reflects the demand for this kind of satisfaction degree and service capabilities in individuality, diversity and high value (Sheu 2007). So, in order to maximize the value creation ability, it must have a standardized theoretical system, method system and policies and regulations to establish collaborative management mechanisms in distribution task management of APEL.

161.3.1 Entities Selection of Quick Response Distribution

The quick response distribution task management in APEL is a multiagent cooperative combat in e-commerce information platform. Therefore, how to achieve efficient multipoint contact in quick response distribution chain of agricultural products? The reliable and stable entities selection of quick response distribution is the key. Under e-commerce environment, the traditional single point contact of customers and enterprise becomes multipoint contacts by taking distribution task as the center (Du and Liu 2011). Through the systematic management, the traditional logistics distribution subjects of market dispersion, disorganisation and low efficiency & benefit are integrated. The integration and optimization ways can be close as well as start with a loose partnership. ECR and JIT theories are their organization basis in quick response distribution chain (Fiedrich et al. 2000). The different logistics management mechanisms and market entities are connected via e-commerce network platform, and to break all sorts of market barriers in APEL. And it changes the traditional vertical organization structure to a flat organization structure. According to integrated management the logistics transportation, warehousing, distribution, circulation processing, suppliers, customers and other related subjects of multilevel, much way and much entities mode, which help to construct efficient APEL distribution chain and improve the overall coordinated quick response ability.

161.3.2 Collaboration Management Mechanisms of Distribution Task

In e-commerce, the demand on quick response between supplier and demander interacts with accompanying cost, service, function and quality. It should improve the quick response and collaborative optimization capabilities of logistics system from system point of view on the basis of the mechanisms management on agricultural products distribution task. Thereby, the distribution task coordination operation management norms and mechanisms formed accordingly. The typical quick response task collaborative management mechanisms in APEL are shown as the following.

(1) *Flexible Matching Mechanism*
The quick response distribution task collaboration management in APEL is a dynamic alliance. It creates value rely on collaborative services of distribution task alliance. On the basis of entities selection on quick response distribution task, it can be constructed as a flexible distribution task management continuum with efficient, seamless integration according to the scientific design of docking strategy and management mechanisms in all distribution tasks collaborative subjects. First, the craft center of distribution task is responsible for decomposing the distribution task, processing plan and design, delivery time quota and lead time management. Then, the distribution task convergence center organizes distribution task cohesion, execution process, optimizes response time and service, function, quality, cost, etc. Finally, the flexible response mechanisms are established combing with e-commerce model of agricultural products and agricultural production, supply policies, and docking standards and system parameters of distribution services organization under the support of modern logistics information technologies.
(2) *Dynamic Equilibrium Mechanism*
The quick response distribution task synergy of agricultural products e-commerce is a comprehensive game in a state of multiagent, multilink and multifactor constraints. It presents a many-to-many condition as a whole. And its management level is various and complex. However, in order to achieve a win–win situation in participates involved, there must be inevitable exists confrontation and compromise, which reflects three dynamic equilibrium mechanisms about power balance, organization balance inside and organizations outside of distribution task. The power balance mechanism of distribution task refers to the organization members hold in their desires

spontaneously and lead to tissue homeostasis based on their own interests. The organization balance mechanism inside refers to the internal mechanism of power allocation equilibrium. The organizations balance mechanism outside refers to the dynamic balance between organizations and their relationships. The dynamic equilibrium of quick response distribution task based on time-based competition connects this three balancing mechanisms with lead time from the whole, and coordinate internal and external, straighten out the vertical and horizontal relations of the power.

(3) *Resources Allocation Mechanism*
The quick response in APEL is a special, comprehensive logistics activities taking sorting and distribution as main means. Its timely delivery and arrival are primary purpose (Zhao and Droge 2001). Faced with this complex distribution system, how to ensure full and effective utilization of the delivery task resource requirements? The rational and efficient resource allocation mechanism is the guarantee (McMichael et al. 2000). Therefore, the distribution resources planning system organizes resources requirements for every optimized distribution task in APEL. And then, it matches demands and supplies according to the constraint rules. For example, firstly, it defines the specific distribution resources for specific task. Secondly, the collaborative management platform of distribution tasks carry out the market oriented resource allocation decision-making with government support. However, all of this is lead by resources property rights theory, distribution market mechanism and resources governance mechanism radically.

Acknowledgments In the current era of rapid development in agricultural products e-commerce, its logistics distribution is the key link of realizing material flow convert to business flow (Hu and Sheu 2003). It is always the bottleneck and important link in quick response logistics development. The collaboration management of quick response distribution task in APEL emphasizes the dynamic task decomposition and coordinative optimization to improve the flexible quick response and adaptation ability on the task of overall system. On the whole, the multilevel task tree and its task assignment and positioned based on the multilevel task tree are used to support flexible task classification system and business processes. According to this, the collaboration management system can realize thickness variable content management, and improve the quick response capability.

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Chapter 162
Control Policies for a Markov Queueing-Inventory System with Two Demand Classes

Ming-wu Liu, Feng Xi and Hong Chen

Abstract This paper considers an (s, Q) Markov queuing-inventory system with two classes of customers, ordinary and priority customers. As and when the on-hand inventory drops to the safety level s, arrival ordinary customers receive service at probability p. Firstly, the inventory level state transitions equation is set up. The steady-state probability distribution and the system's performance measures which are used for the inventory control are derived. Next, a long-run average inventory cost function is established. An improved genetic algorithm for the optimum control policies is developed. Finally, the optimal inventory control polices and the sensitivities are investigated through the numerical experiments.

Keywords Inventory system · Two demand classes · Control · Genetic algorithm

162.1 Introduction

In practice, inventory systems usually satisfy demands from more than one customer class, each of which may possess respective characteristics, such as affordable price, quality of service, etc. Typically, the inventory demand of customers with different characters results in various service forms with priority. A classical example of the type of priority inventory demand that we wish to illustrate is booked orders and unscheduled orders. Booked orders, which are from long-term contracts and have much higher shortage lost, must be satisfied preferentially. Meanwhile unscheduled

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orders from the stochastic demand may bear lower shortage cost, can be lost. The real-life situations and extensive implications stimulate us to consider the queuing-inventory system with two demand classes.

Queueing-inventory systems (Schwarz et al. 2006) have captured much attention over the last decades (Berman and Kim 1999; Berman and Sapna 2001). A queuing-inventory system is different from the traditional queuing system because of the way the attached inventory influences the service. As pointed by Zhao and Lian (2011), If there is no inventory on hand, the service will be interrupted. Also, it is different from the traditional inventory management because the inventory is consumed at the serving rate rather than the customers' arrival rate when there are customers queued up for service". As analyzed by Dekker et al. (2002) a similar system with multiple demand classes, lost sales and Poisson demand and modeled it as an M/M/S/S queueing system and derived expressions for the average cost. Savin et al. (2000) provide an analysis of a multi-class environment in the rental business. As pointed out above models that incorporate two or multiple classes of demands considering possible lost sale for rejecting ordinary customers' demands are rare in the literature. Melchiors et al. (2001) analyzed an (s, Q) inventory system with lost sales and two demand classes for the case of deterministic lead-times and obtained a formula for the total expected cost and presented a numerical procedure for optimization. They based on this equivalence, and developed a model for cost evaluation and optimization under the assumptions of Poisson demand, deterministic replenishment lead time, and a continuous-review (Q, R) policy with rationing.

This paper presents a selected service discipline in an (s, Q) priority queuing-inventory system. When ordinary customers arrive, the system makes a decision whether or not to offer service. Our paper introduces a priority parameter p, which is different from the previous papers on queuing-inventory systems with two classes of customers (Arslan et al. 2007; Isotupa 2006; Zhao and Lian 2011). The parameter p is used for controlling the application of priority. Another difference in this paper is the optimization problem. We setup a mix integer optimization problem and propose an improved genetic algorithm.

162.2 The Model Description

We consider a single server queueing-inventory system serving two classes of customers and subjecting to selected service. There are two classes of customers: priority customers and ordinary customers. The arrival process for both classes is state independent and each customer needs exactly one item from the inventory. Priority customers arrive according to Poisson process with intensity λ_1 and ordinary customers arrive according to Poisson process intensity λ_2. The service discipline is first-come-first-service (FCFS). And, the service will be finished instantaneously (Compared to the lead-time for the order, the customers' order processing time can be omitted). The lead-time is exponentially distributed with parameter μ. We assume that the replenishment is never interrupted and there is at most one outstanding order at any time. We also apply the continuous review (s, Q) policy as in Schwarz et al. (2006), Zhao and Lian (2011), but with an additional selected service. As and when the on-hand inventory drops to a fixed level s (safety inventory level), an order for fixed $Q(> s)$ units is placed. The condition $Q > s$ ensures that there is no perpetual shortage. Hence the maximum on-hand inventory is $s + Q$. When the on-hand inventory is not less than the safety level s, the two classes of customers arrived both can be served. But, when the on-hand inventory drops to the safety level s, arrival ordinary customers receive service at the probability p. These ordinary customers that do not receive service are lost. Also, when the inventory is empty, both classes of customers are assumed to be lost.

162.3 The Steady-State Performance Measures

Let $I(t), t \geq 0$ be the on-hand inventory level at time t. From the model assumptions, the state space of $I(t)$ is $E = \{0, 1, \cdots, s, \cdots, Q, 1 + Q, \cdots, s + Q\}$. For the Poisson input process and the exponential distribution lead-time, the inventory level state next period depends only on the current state and not on any past states. The inventory level process $I(t)$ constitutes a Markov process on state space E. And define the steady-state probability distributions for $I(t)$ as $P(j)$.

In the long run equilibrium, the steady-state probability distributions of the inventory level $P(j)$ satisfy the following Eqs. (162.1)–(162.6). The balance equations can be obtained by the fact that transition out of a state is equal to transition into a state for a Markov process. For example, let us consider a type inventory level state j that line in the range $Q \leq j \leq Q + s - 1$. The equation is represented in Eq. (162.2). When j is in this range, there is no order pending, and then transition out this state can be only duce to either an ordinary demand arrival or a priority demand arrival. This fact represented on the left-hand side of equation Eq. (162.2). Either an ordinary demand or a priority demand in state $j + 1$ will cut down the inventory level by one unit, thus bring it to state j. State j can also be reached from state $j - Q$ when a replacement arrives. The only two possible ways of reaching state j are reflected on the right side of Eq. (162.2).

$$(\lambda_1 + \lambda_2)P(Q + s) = \mu P(s). \tag{162.1}$$

$$\begin{gathered}(\lambda_1 + \lambda_2)P(j) = (\lambda_1 + \lambda_2)P(j + 1) + \mu P(j - Q),\\ j = Q, Q + 1, \ldots, Q + s - 1\end{gathered} \tag{162.2}$$

$$(\lambda_1 + \lambda_2)P(j) = (\lambda_1 + \lambda_2)P(j + 1), \quad j = s + 1, \ldots, Q - 1 \tag{162.3}$$

$$(p\lambda_2 + \lambda_1 + \mu)P(s) = (\lambda_1 + \lambda_2)P(s + 1) \tag{162.4}$$

$$(p\lambda_2 + \lambda_1 + \mu)P(j) = (\lambda_1 + p\lambda_2)P(j+1), \quad j = 1, 2\ldots, s-1 \tag{162.5}$$

$$\mu P(0) = (\lambda_1 + p\lambda_2)P(1) \tag{162.6}$$

The above set of equations together with the normalizing condition written as, $\sum_{j=0}^{Q+s} P(j) = 1$ determine the steady-state probability distributions uniquely. We solve the Eqs. (162.1)–(162.6) by the means of recursive process, and get

$$P(j) = \left(1 + \frac{\mu}{\lambda_1 + p\lambda_2}\right)^{j-1} \frac{\mu}{\lambda_1 + p\lambda_2} P(0), \quad j = 1, 2, \ldots, s \tag{162.7}$$

$$P(j) = \left(1 + \frac{\mu}{\lambda_1 + p\lambda_2}\right)^{s} \frac{\mu}{\lambda_1 + \lambda_2} P(0), \quad j = s+1, s+2, \ldots, Q \tag{162.8}$$

$$P(j) = \left[\left(1 + \frac{\mu}{\lambda_1 + p\lambda_2}\right)^{s} - \left(1 + \frac{\mu}{\lambda_1 + p\lambda_2}\right)^{j-Q-1}\right] \frac{\mu}{\lambda_1 + \lambda_2} P(0), \quad j = Q+1, Q+2, \ldots, Q+s \tag{162.9}$$

$$P(0) = \frac{\lambda_1 + \lambda_2}{\lambda_1 + p\lambda_2 + [Q\mu + (1-p)\lambda_2]\left(1 + \frac{\mu}{\lambda_1 + p\lambda_2}\right)^{s}} \tag{162.10}$$

Inserting (162.10) in (162.7)–(162.9) respectively, we have the analytical steady-state probability distributions of the inventory level.

Let $\bar{I}$ denote the average inventory level. Using $\bar{I} = \sum_{j=1}^{s+Q} jp(j)$, we have

$$\begin{aligned}\bar{\mathrm{I}} = {} & \left(1 + \frac{\mu}{\lambda_1 + p\lambda_2}\right)^{s} \left[\frac{s(1-p)\lambda_2}{\lambda_1 + \lambda_2} + \mu \frac{Q^2 + 2Qs + Q}{2(\lambda_1 + \lambda_2)}\right] P(0) \\ & - \left(1 + \frac{\mu}{\lambda_1 + p\lambda_2}\right)^{s} \left[Q \frac{\lambda_1 + p\lambda_2}{\lambda_1 + \lambda_2} - \frac{(1-p)\lambda_2}{\mu} \frac{\lambda_1 + p\lambda_2}{\lambda_1 + \lambda_2}\right] P(0) \\ & + \left(Q + \frac{(1-p)\lambda_2}{\mu}\right)\left(\frac{\lambda_1 + p\lambda_2}{\lambda_1 + \lambda_2}\right) P(0)\end{aligned} \tag{162.11}$$

Let us denote
$\bar{R} \equiv$ the mean reorder rate
$\bar{\psi}_1 \equiv$ the mean shortage rates for the priority customers
$\bar{\psi}_2 \equiv$ the mean shortage rates for the ordinary customers

The mean reorder rate, the mean shortage rates for the priority customers and the mean shortage rates for the ordinary customers, respectively, are written by

$$\bar{R} = (\lambda_1 + \lambda_2)P(s+1) = \left(1 + \frac{\mu}{\lambda_1 + p\lambda_2}\right)^{s} \mu P(0) \tag{162.12}$$

$$\bar{\psi}_1 = \lambda_1 P(0) \tag{162.13}$$

$$\begin{aligned}\bar{\psi}_2 &= (1-p)\lambda_2 \sum\nolimits_{j=1}^{s} P(j) + p\lambda_2 P(0) \\ &= \left[(1-p)\left(1+\frac{\mu}{\lambda_1 + p\lambda_2}\right)^s + p\right]\lambda_2 P(0)\end{aligned} \tag{162.14}$$

162.4 Inventory Control

162.4.1 Inventory Cost Formulation

This section, we will define an inventory cost function and discuss the analytical property. We establish a steady-state average inventory cost function per unit time, in which s and Q, as well as p are the decision variables. Let us denote the following cost parameters:

h the inventory holding cost per unit per unit time
k the fixed ordering cost per order
c_1 the purchase price per unit
g_1 the shortage cost per unit for the priority customers lost
g_2 the shortage cost per unit for the ordinary customers lost

The system incurs inventory holding costs, fixed ordering cost, purchase costs and costs of lost sales for possibly rejecting two classes of customer orders. Using the definitions of each cost component numbered up above, the total long-run average cost function per unit time is given by

$$\begin{aligned}Cost(s,Q,p) &= h\bar{I} + (k + c_1 Q)\bar{R} + g_1\bar{\psi}_1 + g_2\bar{\psi}_2 \\ &= h\left(1+\frac{\mu}{\lambda_1+p\lambda_2}\right)^s \left[\frac{s(1-p)\lambda_2}{\lambda_1+\lambda_2} + \mu\frac{Q^2+2Qs+Q}{2(\lambda_1+\lambda_2)}\right]P(0) \\ &\quad - h\left(1+\frac{\mu}{\lambda_1+p\lambda_2}\right)^s \left[Q\frac{\lambda_1+p\lambda_2}{\lambda_1+\lambda_2} - \frac{(1-p)\lambda_2}{\mu}\frac{\lambda_1+p\lambda_2}{\lambda_1+\lambda_2}\right]P(0) \\ &\quad + h\left(Q+\frac{(1-p)\lambda_2}{\mu}\right)\left(\frac{\lambda_1+p\lambda_2}{\lambda_1+\lambda_2}\right)P(0) \\ &\quad + c_1 Q\left(1+\frac{\mu}{\lambda_1+p\lambda_2}\right)^s \mu P(0) + g_1\lambda_1 P(0) \\ &\quad + g_2\left[(1-p)\left(1+\frac{\mu}{\lambda_1+p\lambda_2}\right)^s + p\right]\lambda_2 P(0)\end{aligned} \tag{162.15}$$

where, $P(0)$ is given by (162.10).

162.4.2 Optimization Problem

A mixed integer optimization model is constructed here to obtain the optimal inventory control policy which consists of priority rule and order policy. The mixed integer optimization model is presented below:

$$Min\ Cost_{(s,Q,p)} = \{h\bar{I} + (k + c_1 Q)\bar{R} + g_1\bar{\psi}_1 + g_2\bar{\psi}_2\} \quad (162.16)$$

Subject to:

$$s - Q \leq -1 \quad (162.17)$$

$$0 \leq p \leq 1 \quad (162.18)$$

$$s \geq 0 \quad (162.19)$$

$$s, Q \text{ are integer variables} \quad (162.20)$$

The objective function minimizes the inventory cost that is represented by (162.15). Constraint (162.17) is the assumption that there is no perpetual shortage. Constraint (162.18) is the priority identification rule. Equation (162.19) is the non-negative constraint. Constraint (162.20) characterizes the order policy variables.

162.4.3 Algorithm Designing

Suggested algorithms by Isotupa (2006) or Zhao and Lian (2011) fail to solve our problem when certain variables are integer-valued. We adopt a real coded genetic algorithm genetic named MI-LXPM which is introduced by Deep et al. (2009) for solving integer and mixed integer constrained optimization problems. MI-LXPM algorithm is an extension of LXPM algorithm, which is efficient to solve integer and mixed integer constrained optimization problems. In MI-LXPM, Laplace crossover and Power mutation are modified and extended for integer decision variables. Readers who want to read the MI-LXPM algorithm in detail may refer to Deep et al. (2009).

MI-LXPM algorithm can be put in practice on MATLAB R2012a. In the following numerical examples, the initial population contains 30 individuals, crossover probability Pc = 0.8, mutation probability Pm = 0.01. The algorithm stops when the number of generations reaches the value of Generations (2000) or the weighted average change in the fitness function value is less than Function tolerance (1e-6).

Table 162.1 The optimal control policy with the change of λ_2 with two small shortage costs

λ_2	(s^*, Q^*, p^*)	$Cost^*$	$\bar{I}$	$\bar{R}$	$\bar{\psi}_1$	$\bar{\psi}_2$
1	(0, 14,*)	256.2963	6.4815	0.6790	1.3580	0.1358
10	(0, 18,*)	386.8182	7.7727	0.9091	1.8182	1.8182
100	(2, 32, 0)	1.4350e + 03	10.8571	2.0798	1.8487	41.5966
1000	(3, 47, 0)	1.0594e + 04	6.1447	4.0793	2.4174	815.8564

The optimal $p^* = *$ means p is an arbitrary value in [0, 1]

162.5 Numerical Example

In this section, we present an (s, Q) order policy with service discipline p to minimize the long-run average inventory cost function. In the following, we examine the effect of the selected service and investigate the sensitivities of system parameters. The numerical results are summed up as follows.

(1) Case 1: The shortage lost cost of priority customers is twice over the shortage lost cost of ordinary customers, but shortage lost costs of the two classes of customers are small, $g_1 = 20, g_2 = 10$. Let us consider the parameter λ_2 in a situation where $h = 10, k = 100, c_1 = 10,\ \lambda_1 = 10, \mu = 5$.

From the Table 162.1, the long-run inventory cost is increasing in accordance to λ_2. The optimal reorder point $s*$ and reorder quantity $Q*$ are increasing in accordance to λ_2. When $\lambda_2 = 1, 10$, the reorder point $s* = 0$, the optimal p^* is an arbitrary value in [0, 1]. The system is indistinctive between priority service and no-priority service rule. The shortage rate of the two classes of customer is equal. But, the arrival rate of the ordinary customers increase to 100 or 1000, the optimal $p = 0$. That is to say the priority service rule will better the inventory control.

(2) Case 2. The shortage lost cost of priority customers is twice over the shortage lost cost of ordinary customers, but shortage lost costs of the two classes of customers are big, $g_1 = 2000, g_2 = 1000$. The optimal service rule is also no-priority service.

From Case 1 and Case 2, we can conclude that when the two classes of shortage cost are big, the optimal service rule is no-priority for the inventory control, even though the shortage cost of ordinary customers is obviously less than the shortage cost of priority customers.

162.6 Conclusion

In this paper, we consider a Markov queueing-inventory system with two classes of demands, (s, Q) replenishment policy, and subjected to an additional selected service discipline. The main contribution of this paper is the introduction an additional selected service discipline into the queueing-inventory system that endues the inventory management polices much more flexibilities. The current

Table 162.2 The optimal control policy with the change of λ_2 with two bigger shortage costs

λ_2	(s^*, Q^*, p^*)	$Cost^*$	$\bar{I}$	$\bar{R}$	$\bar{\psi}_1$	$\bar{\psi}_2$
1	(12, 18, 1)	392.4398	19.2982	0.6103	0.0136	0.0014
10	(21, 25, 1)	623.7207	29.9926	0.7988	0.0147	0.0147
100	(103, 104, 1)	2.7976e + 03	133.4361	1.0554	0.0217	0.2168
1000	(911, 912, 1)	2.4341e + 04	1.1649e + 03	1.1047	0.0246	2.4575

work can be generalized to the situation where demands arrival is not a Poisson process.

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Chapter 163
Study on the Role of Supplier and Customer Expectation Difference in Relational Satisfaction

Lan Wang

Abstract This paper aims to explore the impact of supplier and customer expectation difference on relational satisfaction. We argue that negative expectation difference will lead to low level of relational satisfaction and innovation performance, because they prevent information sharing and reduce trust. Long-term oriented supplier relationship and supplier involvement in early stage R&D will lead to high level of relational satisfaction and innovation performance. Theoretical and managerial implications are discussed.

Keywords Supplier relationship · Relational satisfaction · Innovation performance

163.1 Introduction

Relational satisfaction has been discussed a lot in marketing channels and channel relationships literature. In early loose channel structure, managers are less aware of the long-term cooperation. Many speculative behaviors occurred based on economic factors dominated. With the formation of increasingly close vertical marketing system, the resources between channel members have become the source of competitive advantage as the establishment of strategic resources, channel power and relational satisfaction.

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163.2 Literature Review

Most scholars have a relatively consistent view on the causes of relational satisfaction. They generally believe that the supplier and customer relationship is inherent in the channel behavior, this is mainly because the functional dependence between the channel members. Channel relational satisfaction may come from the more specific functional relationships. Etgar (1979) argued that the goal of inconsistencies, and seeking independence and control have led to a dominant conflict. Stern found that the diversified goals and different view on market are the main factors affecting the field of channel conflict (Stern et al. 2000). Gattorna (1978), Rosenberg and Stern (1970) through empirical research found that the greater the goal differences will result in more channel conflict. In the integration model of channel conflict, Michman and Sibley proposed five factors that may affect the channel conflict: environmental factors, the nature of channels structure, channel mode, the position of the channel members and industry standards. The five elements contain both microeconomic factors and macro factors. Macroeconomic factors such as environmental factors beyond the control of channel members, some elements will enhance the channel cohesion, some elements will lead to tension leading to low level of relational satisfaction between channel members.

Empirical research on channel structure as the mediating variables of power and conflict in the relational model showed that the impact of reward power and coercive power of the conflict depends on the channel members for the channel decision-making structures awareness. Studies have shown that reward power and coercive power not directly linked to channel relational satisfaction but through the mediating variables of the decision-making structures (Patrick and Emin 1998). Etgar (1979) divided conflict into potential and appeared conflicts and study the impact of conflict factors into two categories of structural factors and subjective factors. Conduct research in six different industries concluded that the potential conflict or apparent conflict by subjective factors (differences in perception, expectation differences, role ambiguity, the impact of communication barriers, etc.).

163.3 Negative Expectation Difference and Relational Satisfaction

Throughout the literature research we found that many influential factors of channel relational satisfaction, put forward by different scholars have some overlap. It can be divided into macro influencing factors and micro-influencing factors. Rosenberg summarized the literature and found the reasons for relational satisfaction in the channel can be included in one or more of the following seven basic reasons: the role of difference, the scarcity of resources, differences in perception, expect differences decision-making differences, the inconsistent goal, communication barriers (Bert 2002). In addition, the power often usually as a conflict of individual antecedent variables to study the impact on low level of relational satisfaction (Nagel 1975).

For a short period of time, change of political, economic, cultural, technological and legal environment in a customer relationship life cycle stages is relatively stabilized. Understanding and expectations of the role of behavior in the channels between the members of the role of lead differences in channel relationships more apparent, the impact of this relatively micro-level factors are more complex. Stern argued that there are mutually exclusive or incompatible goals, values or interests between channel members when conflict occurs. He believes that the channel relational satisfaction factors, including the difference of objectives, a realistic view of the different areas which consists of four elements: the target population, geographic coverage, the need to complete the task, and the marketing problem. The objective is how to achieve the overall objective of channels. Each channel member will have their own opinions and requests. For example, manufacturers would like to occupy a larger market, more sales to middlemen and increase profits. Vendors do not care about sales which brand. Therefore, when the channel members' individual goals appear incompatible, conflict will inevitably happen. Areas of difference, refers to the channel members in the ownership of the target customer, sales region, division of channel function and technical aspects of the existing contradictions and differences.

These contradictions and differences, if not handled properly will lead to conflict. The reality of cognitive differences between the channel members channel events, the views and attitudes of the state and forms of differences. Such differences include: the understanding of the current state of real events, and forecast its future development possibilities and choices of information to understand the situation, on the understanding of the consequences of a variety of choices, and understand the goals and values differences. Awareness of the channel members depends on their previous experience, as well as the quantity and quality of access to information. The greater the differences result in more channel conflict. Michman and Sibley in the integrated model of channel conflict, from the macro point of view put forward the five factors that may affect the channel conflict: environmental factors, the channel junction on the nature of the organizational structure, the channel model, the positioning of the channel members and industry standard, but no empirical research.

Expectations refer to the different channel members would expect the behavior of other members. In fact, these expectations is predicted that the future behavior of other channel members (Baron and Byrne 1997). Negative expectation difference refers to channel members the expected higher performance for other members than their actual behavior. That is the real performance less than expected performance, including equal. Sometimes predictable result is inaccurate, and to predict the channel members often take action based on the expected results. This reaction has not previously forecast or does not occur may result in other members to make the inappropriate action. The theoretical foundation of the expected differences in social psychology and experimental psychology is widely used to explain the marketing literature, customer expectations, the relationship between the product/service performance and customer satisfaction (Oliver 1980).

Expectation differences in the model are to explain the basic idea of customer satisfaction. Subjective evaluation of customers will the current product/service performance and to buy before the desired level of performance compared to the formation of a real performance and expected performance differences, the magnitude and direction of this difference determine customer satisfaction with the direction and extent of (Oliva et al. 1992). If it a negative difference, the customer is not satisfied. The greater the negative difference, the more satisfied customers. Recent studies have been to expand the desired difference mode: the mode of product/service performance to expand value for customers, product/service performance of just one aspect of customer value. The expected performance is to expand the desired customer value. Obviously, from the expectations of differences in mode of view, the main factors affecting customer satisfaction, customer value and customer expectations and providers.

The manufacturer is limited to the regulation and control of customer expectations, customer value determinants of customer satisfaction. From a strategic point of view, the technology diffusion accelerates shorter product life cycle. Enterprises should pay attention to their own creative abilities to provide unique value-added services for our customers and build sustainable customer loyalty. Customer satisfaction was negatively correlated with the level of channel conflict. The higher channel member' satisfaction is, the lower level of conflict is. The causes of channel conflict due to the interest. Therefore, the greater the negative expectation difference is, the lower the perceived customer value is. This will result in lower customer loyalty and lead channel relationships to the recession. We assumed that the supplier and customer negative expectation difference is negatively correlated with the levels of relational satisfaction.

163.4 Sample and Data Collection

Based on literature search and previous case studies, we developed a questionnaire. The data was collected in Wenzhou area of mainland China from the early May of 2007 to the late November of 2007. 600 questionnaires were sent to the firms' managers from the city of Rui'an and Yueqing. The returned valid questionnaires are 194 pieces, resulting in an effective respond rate of 32.3 %. There were no significant differences between responding ventures and non-responding ventures in terms of venture size and age (Table 163.1).

We controlled for the following variables: Industry referred to the industry the firm belongs to, including Automobile, Electric Appliance, Machine and equipment manufacturing, Clothes and shoes, Consumer products, foods, Communication, and service industry. Second, Business type; Third, Firm size; Fourth, Previous research suggested that R&D spend and innovation performance might

Table 163.1 Distribution of respondents

Sales revenues (in million RMB)	N	%
Less than 1	3	1.5
1–5	6	3.1
5–10	12	6.2
10–30	38	19.6
30–100	83	42.8
Above 100	52	26.8
Total	194	100
Business types		
Manufacture	97	50.0
Manufacture and distribution	63	32.5
Wholesale and distribution	16	8.2
Retailing	7	3.6
Other services	11	5.7
Total	194	100

vary by sale Revenues and total asset, which were added to the framework. Finally, because the sample was from different areas and district, culture and education level may vary, we coded the cases according to the district

163.5 Conclusion and Implication

We conduct empirical study and test results show that in customer relationship maturity period expectations of negative differences and relational satisfaction level was significantly negatively correlated, and consistent with the hypothesis. In the process of customer relationship development, the retailer always continually assess the relative value provided by the manufacturer, but comparative reference point changes over time. In the beginning period and the formation period, due to limited understanding of alternative manufacturers, as well as the assessment of the value of their own capacity constraints, comparative reference point helps to establish a similar relationship based on past experience and expected value.

In maturity, with the increase of understanding of alternative manufacturers and evaluation their capabilities, the customer's perspective broadens, the evaluation changed from an internal to external view. The negative difference will make a party to the other party as to impede the obstacles to achieve higher goals, resulting in exit intention. If not promptly take appropriate measures to repair the relationship and increase customer value, the members will exit channels. The relationship will soon enter the recession stage. When the channel members show a discordant loyalty, given the transfer costs and other factors, the retailers will have to choose alternative innovative manufactures and suppliers.

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Chapter 164
The Study on the Synergy of Corporate Stakeholders in the Corporate Governance: Based on the Theory of Complex Systems

Chuan-jun Li

Abstract It appears to be a new approach of study that adopting the theory of complex systems on the study of corporate stakeholders. The emergence, development and growth of corporate stakeholders' system can be satisfactorily analyzed in the theory of self-organization. The theory of complex systems originated from system theory is a result of transition from system theory to nonlinear science of complexity, and a theory of study on self-organization phenomena and laws. Dissipative structure theory deeply unearths the birth environment and conditions of self-organization and lays the foundation for the theory of self-organization; and synergetics theory intends to explain the process in which a system evolves from disorderliness to orderliness, which is essentially a process of self-organization inside the system. Synergy is a form and mean of self-organization. As a social system, corporate stakeholders' system is a complex aggregation of multiple factors, themes and relations, has a series of conditions for self-organization, and its evolution is driven by the synergy among all the subsystems inside the system. On the whole, the process of synergetic evolution is normally the development from the evolution of competitive synergy to the evolution of cooperative synergy.

Keywords Theory of complex systems · Corporate Stakeholders' system · Dissipative structure · The theory of synergetics · Mechanism of evolution

164.1 Introduction

Since Menas and Berle brought forward the famous theory that the separation of the control rights and the ownership in the Modern Corporation and Private Property in the 1930s, corporate governance has always been the focus of

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enterprise economics because the issue of corporate governance came into being with the separation of ownership rights and controlling rights.

Before 1980s, almost all scholars thought that the shareholders were the owner of firms. As a result, shareholder primacy and private property primacy were golden rules in market economy. Material capital was considered as the foundation for firms, thus shareholder naturally monopolized the ownership of firm and had the unique high position.

But from the beginning of 1990s, the theory of shareholder primacy has been seriously challenged by stakeholder. With the rapidly increase of importance of other capital, especially the human capital, other stakeholders don't want to be ignored by corporate governance and continue with their watching. So the other stakeholders' desire of taking part in allocation of corporate right gets much stronger. Under this situation, the co-governance by stakeholders becomes an important model in the area of corporate governance.

Corporate governance is indeed the arrangement of corporation's institution, whose essence is the fight for firm's power and profit between all stakeholders. As a result of long evolution about corporate governance mechanism, the co-governance by stakeholders will become a new trend about corporate governance.

In co-governance model, how to allocate the firm's right and profit is the core problem. From the review of relevant research, many measures and models have been used. In this paper, the theory of complex systems is used.

As a social system, corporate stakeholders' system (or corporate stakeholders cluster) is a complex aggregation of multiple factors, themes and relations, has a series of conditions for self-organization, and its evolution is driven by the synergy among all the subsystems inside the system. On the whole, the process of synergetic evolution is normally the development from the evolution of competitive synergy to the evolution of cooperative synergy.

164.2 Review of the Relevant Theory

The theory of complex systems, also called the theory of self-organization and originated from system theory, is a result of transition from system theory to nonlinear science of complexity, and a theory of study on self-organization phenomena and laws. Currently, it is not a unified theory yet, but a group of theories (Wu 2001). Then, what is complex system? I. Prigogine initiated and applied the concept of "self-organization" accurately, "a system shall be considered as a self-organization if it is free of external interference during its process of acquiring the spatial, temporal or functional structure. The word 'specific' means that such a structure and function is not imposed on the system by outside world, and the outside world affects the system in an unspecific way". Haken further specifies that an orderly organization that is formed concertedly and automatically by a system when doing their respective duties in a tacit principle, if there is no external command, is considered as self-organization. The theory of complex systems mainly contains: (1) I. Prigogine's Dissipative Structure Theory, which deeply unearths the birth environment and conditions about the self-organization of complex systems and lays the foundation for the theory about the self-organization of complex systems; (2) H. Haken's Synergetics Theory, which presents the inner mechanism in the formation about the self-organization of complex systems; (3) Thom's Morphogenesis Theory, which particularly demonstrates the path of evolution about the self-organization of complex systems; (4) Eigen's Hyper cycle Theory, which analyzes the specific form of self-organization evolution and the process of combination for systems; (5) Mandelbort's Fractal Theory, which identifies the similarity between the part and the whole of system so as to provide a very effective method for generating and understanding complexity; (6) and Lorentz's Chaotic Theory, which employs the Butterfly Effect (Cilliers 1998) in the nonlinear determination formula to further reveal the origin of fractal structure from dynamics and the universal law of evolution for nonlinear system. Therefore, people have deepened their understanding of system existence and development, begun going beyond the range of closed system theories from the mechanistic perspective gradually and explained the conditions and mechanism of system evolution and development from different angles and levels (Fig. 164.1).

Generally speaking, the evolution process about the self-organization of complex systems is a process in which a system experiences the continuous improvement of orderliness from simplicity to complexity, disorderliness to orderliness. Self-organization is a dynamic process, so it is a process of evolution from disorganization to organization, low degree to high degree of organization and simplicity to complexity in the same level.

In the field of economics, the theory about the self-organization of complex systems has been employed in the study on the complexity of economic system in the world ever since the 1980s. For instance, Arrow et al. organized a seminar on

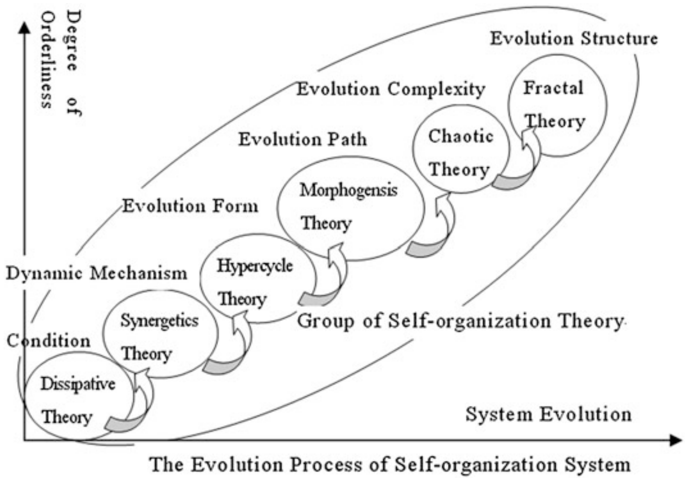

Fig. 164.1 The evolution process of self-organization system

considering economy as a complex evolution system in 1988, and argued that economic system must have a core mechanism of dynamics, which could be defined by parameters of few dimensions and variables of multiple dimensions and dominate the evolution of whole economic system (Arrow 1988). After studying the economic balance and evolutional drive, Arthur has initiated the non-equilibrium and evolutionary nonlinear complex economics, and pointed out that the linear model frequently used in the economic analysis shadows the inner complexity and authenticity of economy (Arthur 1989). An economist Peters Edgar adopts fractal and chaos in the study on the financial market, tremendously shaking the analytic paradigm in the mainstream financial economics (Peters Edgar 1994). Some scholars represented by Cilliers employ the theory of self-organization to study the complex adaptation system in which multiple subjects interact (Andrei and Robert 1996).

In recent years, as the study on corporate stakeholders' system has become a hot topic, a lot of scholars have started discussing about such issue with the theory about the self-organization of complex systems.

164.3 Formation of Corporate Stakeholders' System and Self-Organization Conditions

In 1969, I. Prigogine, a Nobel Prize winner of chemistry, brought forth the notion of dissipation at the International Conference on Theoretical Physics and Biology. In 1971, Prigogine et al. published a book named *Thermodynamic Theory of Structure, Stability and Fluctuations*, which detailed the theory of Dissipative Structure. In 1977, Prigogine et al. published another work *Self-Organization in Non-Equilibrium Systems*, further developing the theory of Dissipative Structure.

When studying the process of a system from equilibrium to nearly equilibrium and then non-equilibrium, Professor Prigogine found that an open system, when it enters the nonlinear district away from equilibrium, may move from stability to instability once a parameter in the system reaches a specific threshold, and experience a morphogenesis due to fluctuation, in other words, non-equilibrium phase change. Therefore, the existing disorderly chaos is changed to a new orderly state. Such a new orderly structure formed in the nonlinear district away from equilibrium could be maintained by a continuous exchange of material and energy with outside world, and its stability would be kept by means of energy dissipation and not eliminated by any tiny interference by outside world. Prigogine called such a structure as Dissipative Structure and the phenomenon as Self-organization.

The theory of dissipative structure has, through the methods of thermodynamics and the system stability analysis, scientifically proven that an open system away from equilibrium can have a dissipative structure only if it has some conditions. These conditions include: (1) System openness, which guarantees the exchange of material, energy and information between an organization and outside world, and a system can be alienated from equilibrium only if it is sufficiently open; (2). System away from equilibrium, as a system in the state of equilibrium and nearly equilibrium cannot develop toward orderliness automatically, the away from equilibrium disintegrates the existing structure of the system rapidly and forms the dissipative structure by means of self-organization, which cannot only lead the system to orderliness, but also causes the diversified paths of organization evolution; (3). There must be an autocatalytic nonlinear interaction inside a system, since the nonlinear interaction among all factors can rapidly amplify any little difference or occasional fluctuation, and make the positive feedback viewed as a destructive factor from the approach of an equilibrium system become a constructive factor in the system evolution; (4). Effect of fluctuation, which drives a system to form a new orderly structure out of its existing structure, and whether the degree and range of fluctuation exceeds the critical state can be a decisive factor to judge whether the system has self-stabilization or self-restructuring.

If corporate stakeholders' system, as a special sub-system of economic system, is carefully analyzed, it will be found that it has a series of conditions for dissipative structure (Aoki 2003).

164.3.1 Corporate Stakeholders' System is an Open Self-Organization System

It is firstly demonstrated that corporate stakeholders' system is developed within a specific space of advantageous location. In the dynamic process, stakeholders keep entering and quitting continuously, which maintains a certain degree of malleability for the organization structure of stakeholders. It is secondly demonstrated that the existence of system must depend on the exchange of resources and the frequent exchange of labor flow, material flow, capital flow, information flow and other factors between corporate stakeholders' system and external environment can form a negative entropy flow so as to cause the formation, maintenance and evolution of orderly structure in the corporate stakeholders' system.

164.3.2 The Corporate Stakeholders' System has a Typical Feature of Nonlinearity

Linearity refers to the scaled and linear relation between quantities, which represents the regular and smooth movement in space and time; while nonlinearity refers to the relation that is not scaled or straight, which represents the irregular movement and morphogenesis. The nonlinear system means the mathematical model of a system cannot satisfy the principle of superposition or may contain the nonlinear link. The corporate stakeholders' system is a nonlinear system. Due to the effect of nonlinearity, a system can acquire new properties and realize the functions beyond the mechanical aggregation of functions owned by its member.

164.3.3 The Difference of Stakeholders Results in the Corporate Stakeholders' System Away from Equilibrium

Due to their different capabilities, stakeholders have formed the specialized division and cooperative relationship, alienating corporate stakeholders' system from equilibrium. Moreover, the bigger difference between stakeholders, the larger deviation from equilibrium and the more easily corporate stakeholders' system forms the nonlinear system of competition and synergism. In this way, one or several trend(s) in the evolution of corporate stakeholders' system develop a general trend in the end, so as to lead corporate stakeholders' system to gain the overall competitive advantage by means of self-organization.

164.3.4 Fluctuation Can Help Corporate Stakeholders' System Realize the Equilibrium Development

In the evolution process, corporate stakeholders' system will be inevitably affected by internal and external factors, which triggers the fluctuation in the self-organization of stakeholders. Corporate stakeholders' system should make full use of the effect of internal and external factors to create the conditions for self-organization and synergistic movement, form the active mechanism of fluctuation, avoid the trend of chaos and regeneration, facilitate the trend of orderliness and evolution and realize the equilibrium development maximally.

164.4 Dynamic Mechanism of Corporate Stakeholders' System

Synergetics, also known as synergism or science of synergy, is an emerging subject gradually formed and developed based on the interdisciplinary study since the 1970s and an important theoretical branch of system science. It was initiated by Hermann Haken, a professor in University of Stuttgart of the Federal Republic of Germany and a famous physicist. He put forth the concept of synergy in 1971 and discussed the theory of synergy systematically in 1976. He published *Synergetics: An Introduction* and *Synergetics: Introduction and Advanced Topics*, etc.

The so-called synergy refers to the coordinative (collaborative) simultaneous development. In Haken's opinion, it refers to the associative action of multiple subsystems in a system. No matter how complex a system is, a synergism must exist only if there is the connection, cooperation or coordination among the behavioral agents or subsystems in a system. We define that synergy refers to the uniformity and harmony in the organic connection, cooperation and collaboration of various factors inside an object or a system in the process of connection and development.

Synergetics intends to explain the process in which a system evolves from disorderliness to orderliness, which is essentially a process of self-organization inside the system. Synergy is a form and mean of self-organization. Hence, it can be believed that self-organization is a fundamental path for a system to achieve the development from the disorderly instability to orderly stability and realize its self-improvement and self-development.

As a social system, corporate stakeholders' system is a complex aggregation of multiple factors, themes and relations, and its evolution is driven by the synergy among all the subsystems inside the system. On the whole, the process of synergetic evolution is normally the development from the evolution of competitive synergy to the evolution of cooperative synergy. In the initial stage of cluster aggregation, a few stakeholders start aggregation, take a competitive attitude for their own survival, and make efforts to gain the competitive advantage in order to win their identification in the market. Through such competition, these stakeholders can learn from and adapt to each other, promote the level of stakeholders, actually maintain the common interests between stakeholders and gradually increase the scale of aggregation (Bushman et al. 2004; Monks 2001).

In order to facilitate the analysis on the issue, we assume that there are two stakeholders in an corporate stakeholders' system. By means of the Lotka-Volterra model in the ecology, the evolution of competitive and cooperative synergy among the stakeholders in a cluster can be embodied in the following model:

$$\begin{cases} \dfrac{dN_1}{dt} = F_1(N_1, N_2) = r_1 N_1 \left(\dfrac{K_1 - N_1 - \alpha_{12} N_2 + \beta_{12} N_2}{K_1} \right) \\ \dfrac{dN_2}{dt} = F_2(N_1, N_2) = r_2 N_2 \left(\dfrac{K_2 - N_2 - \alpha_{21} N_1 + \beta_{21} N_2}{K_2} \right) \end{cases}$$

In which, $N_i \geq 0$ stands for the yield of stakeholder i in the cluster; r_i stands for the natural growth rate of yield of stakeholder i; $K_i > 0$ stands for the maximum yield during the independent survival of stakeholder i under the condition of certain resources; $\alpha_{ij} \geq 0$ stands for the coefficient of competition between stakeholders, representing the competitive inhibition of unit yield of stakeholder j to the yield of stakeholder i; β_{ij} stands for the coefficient of cooperation, representing the cooperative and reciprocal effect of unit yield of stakeholder j on the yield of stakeholder i, i,j = 1,2.

(1) *When* $\alpha_{12} > 0$*,* $\alpha_{21} > 0$ *and* $\beta_{12} = \beta_{21} = 0$*, there is the competition between stakeholder i and stakeholder j, so the original differential equations should be changed to:*

$$\begin{cases} \dfrac{dN_1}{dt} = F_1(N_1, N_2) = r_1 N_1 \left(\dfrac{K_1 - N_1 - \alpha_{12} N_2}{K_1} \right) \\ \dfrac{dN_2}{dt} = F_2(N_1, N_2) = r_2 N_2 \left(\dfrac{K_2 - N_2 - \alpha_{21} N_1}{K_2} \right) \end{cases}$$

(2) *When* $\alpha_{12} = \alpha_{21} = 0$*,* $\beta_{12} \neq 0$ *and* $\beta_{21} \neq 0$*, there is the reciprocity between stakeholder i and stakeholder j, so the original differential equations should be changed to:*

$$\begin{cases} \dfrac{dN_1}{dt} = F_1(N_1, N_2) = r_1 N_1 \left(\dfrac{K_1 - N_1 + \beta_{12} N_2}{K_1} \right) \\ \dfrac{dN_2}{dt} = F_2(N_1, N_2) = r_2 N_2 \left(\dfrac{K_2 - N_2 + \beta_{21} N_2}{K_2} \right) \end{cases}$$

(3) *When* $\alpha_{12} \neq 0$*,* $\alpha_{21} \neq 0$*,* $\beta_{12} \neq 0$ *and* $\beta_{21} \neq 0$*, there is the evolution of competitive and cooperative synergy between stakeholder i and stakeholder j, and*:

(a) *If* $\alpha_{12} - \beta_{12} > 0$ *and* $\alpha_{21} - \beta_{21} > 0$*,* the effect of competitive inhibition is stronger than the effect of cooperative reciprocity between stakeholders;
(b) *If* $\alpha_{12} - \beta_{12} < 0$ *and* $\alpha_{21} - \beta_{21} < 0$*,* the effect of cooperative reciprocity is stronger than the effect of competitive inhibition between stakeholders;
(c) *If* $\alpha_{12} - \beta_{12} < 0$ *and* $\alpha_{21} - \beta_{21} > 0$*,* the effect of cooperative reciprocity is stronger than the effect of competitive inhibition imposed by stakeholder 2 on stakeholder 1, and the effect of competitive inhibition is stronger than the effect of cooperative reciprocity imposed by stakeholder 1 on stakeholder 2;
(d) *If* $\alpha_{12} - \beta_{12} > 0$ *and* $\alpha_{21} - \beta_{21} < 0$*,* the effect of cooperative reciprocity is stronger than the effect of competitive inhibition imposed by stakeholder 1 on stakeholder 2, and the effect of competitive inhibition is stronger than the effect of cooperative reciprocity imposed by stakeholder 2 on stakeholder 1.

If the above model is further expanded to a model for the evolution of competitive and cooperative synergy in a cluster of numerous stakeholder s, it is concluded as follows:

$$\begin{aligned} \frac{dN_i}{dt} &= F(N_1, N_2, \ldots, N_n) \\ &= r_i N_i \left(\frac{K_i - N_i - \sum\limits_{j \neq i}^{n} \alpha_{ij} N_j + \sum\limits_{j \neq i}^{n} \beta_{ij} N_j}{K_i} \right), \quad i, j = 1, 2, 3, \ldots, n \end{aligned}$$

As indicated in the above analysis, only the close cooperation among stakeholders can, in the evolution process of corporate stakeholders' system, facilitate the overflow of benefits among stakeholders and the prominence of synergistic effect in the industrial cluster. Competition is a preface to cooperation, so such a competition should be not a fight to death, but a contest of emulation, and the evolution of competitive and cooperative synergy is a drive to the development of industrial cluster. Only if the core structure, supporting system and external environment system in the system of corporate stakeholders' system realize the evolution of overall synergy and all stakeholder s in a cluster can develop harmoniously, a cluster can grow stronger continuously and gain an advantageous position. Therefore, the transition from evolution of competitive synergy to evolution of cooperative synergy is the trend and law of evolution for corporate stakeholders' system (Moerland 1995; Morley 2000).

164.5 Countermeasures and Recommendations

164.5.1 Reduce the Restriction, Enhance the Freedom of Subjects in the System and Facilitate the Great Development of Corporate Stakeholders' System at the Edge of Chaos

According to the theory of self-organization, a system is most creative and it is most possible to have all kinds of innovative activities when the system stays in the narrow critical state, in other words, at the edge of chaos. The persistent state is very stable and lack of vitality, so it goes against the mutual effect of subjects, the mutual learning of stakeholders, the overflow of knowledge and the innovation of cluster; while the absolute state of chaos is too messy and disorderly, so the overmuch competition in a cluster damages the environment of survival for stakeholders as the subjects of self-adaptation, which will result in the lack of trust among stakeholders and affect the synergy evolution and cooperation among stakeholders in the system. Thus, the optimal state for the development of corporate stakeholders' system is the state between orderliness and chaos, or at the edge of chaos. In such a case, a system has the advantages of both orderliness and chaos, but does not have their disadvantages. Therefore, it enjoys sufficient stability but no rigidity, and has sufficient flexibility but little chaos. In this way, the vitality of stakeholders and a system can be sufficiently demonstrated.

164.5.2 Establish and Perfect the Supporting System for the Development of Corporate Stakeholders' System so as to Realize the Synergy Evolution

A supporting system is an extensional support of providing capital, technologies, talents, management and services for the development of corporate stakeholders' system and a strong backup force to maintain the continuous development of corporate stakeholders' system. It can provide the support for the development of corporate stakeholders' system. A supporting system must achieve the coordinated development in correspondence with the development of core structure. Normally, an industrial cluster of self-organization starts attracting various service structures to join in gradually after its core structure is enriched and very strong to a certain degree, and its supporting system is improving gradually. Corporate stakeholders' system is a complex system and its core structure must have the correspondence, joint development and synergy evolution with the supporting system, so as to realize the balanced development of industrial cluster. Overall, the supporting system relatively falls behind the core structure in various corporate stakeholders' system in China, dramatically restricting the healthy development of clusters.

164.5.3 Promote the Communication and Cooperation Between Subjects in a System and Facilitate the Overall Appearance of Systems

The extensive and deep communication and cooperation among stakeholders in a cluster can greatly help absorb internal information and share knowledge so as to facilitate the integration of information and knowledge as well as innovation. After achieving the sharing of benefits and realizing the real profits through cooperation, it can also facilitate the further development of closely associative network under the effect of positive feedback, develop the habit of regular and irregular communications and evolve into a system culture of cluster, which can facilitate the overall appearance of clusters.

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Chapter 165
The Research of Cash Flow Management in Group Enterprise

Rui Hou, Hong Yin, Jin-yuan Zhong and Cun Li

Abstract Cash is the important assets of enterprise, and cash flow is compared to the enterprise's blood, which is formatted by the cash inflow and outflow. Combining with the present situation of the current cash flow management research and the general flow of cash flow management of group enterprise, some existing problems of cash flow management situation of L Group enterprise had analyzed. And cash flow management model of L Group enterprise was put forward in the paper, from those aspects of in construction of the organization, cash flow analysis, budget management, operation management, risk control, performance evaluation and system guarantee.

Keywords Cash flow · Cash flow budget · Cash flow management · Group enterprise

165.1 Preface

Cash is the important assets of enterprise, and the cash flow is formatted by the cash inflow and outflow. The cash flow has reacted vitality of the enterprise, which is very important to the enterprise, and a powerful enterprise must have sustained, healthy cash flow (Gao and Wang 2004). In recent years, the sudden collapse of large enterprise groups, which has worldwide influence, like Enron, Worldcom, Electric Group, American Airlines, Lehman Funds, make people increasingly

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realize the important role of cash flow. In a sense, the ability of the enterprise to obtain cash is more important than profit ability. The purpose of cash flow management is to ensure the required cash of the production and operation activities of enterprises, save money as far as possible, and spend spare cash on investment, then to get more investment income (Duan 2007). Profit is the embodiment of the enterprise profitability, certain profit is the embodiment of the enterprise, which is sustainable development, and profits that can more turn to cash is related to the survival and sustainable development of the enterprise. Enhance the level of the enterprise's cash flow management, which means improve the survival and the ability of sustainable development of the enterprise.

Through by analysing the general model of cash flow management of group enterprise, and combining with present situation of cash flow management of L Group, the problems of cash flow management of L Group had proposed, and the model of cash flow management of group enterprise had tried to build in the paper. This will be improvement action to cash flow management of L Group, and have certain guiding significance to improve the management level of group.

165.2 Cash Flow

The concept of cash flow is defined as the inflow and outflow of cash and cash equivalents. The "cash" of cash flow include not only cash on hand of enterprise basic account, but also deposit, deposit in other city, bank draft deposit, cashier's order deposit, monetary capital deposits that's on the road and other monetary funds, that are deposited in the financial enterprise and can be used to pay at any time, which are including in adjust accounts of enterprise account. Cash equivalents generally refers to investment of the enterprise hold, which is short term, liquidity, easily converted into cash and changes in small of value. For example, the short-term debt of three month that the enterprise hold (Gan 2009).

According to the exercise direction classification, cash flow can be divided into two kinds of cash inflow and cash outflow (Robert and Heller 2006). Cash inflow refers to the cash that flow from the outside to the enterprise. It include market products, service revenue, foreign borrowing, asset recovery, investment recovery, equity funds absorption, etc. Cash outflows refers to the cash that comes out of enterprise. It mainly includes cash payments of the purchase of raw materials and labor services, the distribution of profits, investment spending, taxes to be turned over, worker pay and other activities.

According to the entity nature and movement purpose classification, Cash flow can be divided into cash flow of business activities, cash flow of investment activities and cash flow of financing activities. According to the process of investment projects, it can be divided into initial cash flow, operating cash flow and end cash flow (Bai 1993).

165.3 The Problems of Cash Flow Management in Group

L group enterprise was founded in September 2001, and is joint-stock enterprises of State-owned that is held by Yunnan Copper (group) Limited Company. The company registered capital has 600 million yuan, and the main business is the production and the sales of copper, nickel and cobalt, molybdenum, iron and other ore concentrate, smelting of copper nickel and cobalt molybdenum, mining development and technical services.

165.3.1 The Centralized Management Problems

L Group has some existing problems in the cash centralized management. First of all, the permissions of Group fund group is too small, and Group fund group, which is the core department of cash flow management of L Group, is just the subordinate departments of group financial department. Therefore, it often faces with the problem of insufficient permissions in the treatment of the cash flow problems. At the same time, although group affiliated enterprise shall be turned over to capital according to the request, the enterprise can retain a part of the capital according to oneself circumstance. When it meets the situation of require pay, enterprise turn to the Group, and many of the subordinate enterprise accumulate a considerable sum of money, then it improve the capital cost of enterprise. Meanwhile, the funds of subordinate enterprise shall be turned over to headquarters, and demand funds is appropriated according to the budget request. All of this has increased the complexity of the fund flow program and the difficulty of group management.

165.3.2 The Existing Problems of Cash Flow Budget

The existing problems of the cash flow management model in Group mainly displays in:

(1) Group's budget management system is not perfect, which is the cause of budget consciousness weak of group department. The group has not put cash flow management into the goal of enterprise strategic management and establish a corresponding organizational structure, and cash budget is just the extension and development on the basis of budget of the financial department. Many departments think that budget is just the responsibility of financial departments, so it shall be formulated and managed by the financial department.
(2) The budget has a big deflection in the actual execution, and the restriction of group budget is small. The member enterprise often isn't good implement the

provisions of the budget in specific executive, and the randomness is bigger, and cause group the shortage of funds. In some degree, it's caused by that the budget isn't timely dynamic update and adjust.

(3) The change of cash flow budget is too arbitrary, and can't effectively support group operating decisions. When there are large group temporary payments, it's usually the group leader after the decider, the related departments of group modify the budget according to decisions.

165.3.3 The Shortcomings of the Cash Flow Management Evaluation System

Cash flow management evaluation index lack, and the group often only set absolute index as the main evaluation in the inspection, which include increase or decrease in quantity of total cash, balance contrast with previous years and so on, and set relative data of cash flow balance contrast with previous year as cash flow budget implementation analysis basis, so it lack more detailed cash flow profit, operating performance, the debt repayment ability and other index.

165.4 The Establishment of Cash Flow Management Control Model in L Group

The improved cash flow management processes of L Group include five aspects contents: cash flow management organization, cash flow analysis, cash flow budget management, cash flow risk control, cash flow management, performance evaluation, in order to combine cash flow, enterprise organizational with business activity organically, then achieve to manage and effectively control cash flow (Wang 2007).

165.4.1 Setting Cash Flow Management Organization

The Group set up cash flow management committee to replace the original financial groups to strengthen the Group's cash flow management. It's necessary to set a specific organizational framework for the cash flow management committee to ensure the cash flow management goals. The framework include four management control system: cash flow management committee, cash flow management organization department, cash flow centralized management department, cash flow management responsibility department.

Cash flow management committee is the core departments of the L Group's cash flow management, and it's directly responsible for the Group's Board of

Directors. The members is composed by the Group's general manager, deputy general manager that responsible for the financial and each functional department leaders.

Cash flow management committee is responsible for formulating the group's cash budget, and developing the Group's cash flow management goals according to the Group's strategic goal, coordinating the business decision of the subordinate member enterprise to maintain the safety of the group cash flow.

Cash flow management departments is located in the L group's financial center, that supervise and manage group cash budget execution under the leadership of the group cash flow management committee. By comparing the execution results with the budget difference, find out the reasons and feedback to the related department.

Cash flow centralized management is L Group and the relevant department of it's subordinate enterprises. It's responsible for directly managing the cash flow payments that is related with their own business scope, and initially reviewing cash inflow and outflow that business generated. Through centralized management of cash flow, it made clear the responsibility of the centralized management departments in the preparation and control of cash flow and ensure the effectiveness of cash flow control.

Cash flow management responsibility department mainly refers to the member enterprises of L Group subsidiaries. Due to the dual nature of management and services, each cash flow centralized management may also be a separate responsibility unit.

165.4.2 Cash Flow Analysis

Cash flow analysis are analyzed mainly through data indicators in group cash flow statement. Mainly includes the inflow and outflow of cash flow structure analysis, the net cash flow analysis, debt paying ability analysis, earnings quality analysis (Chen 2008).

(1) Cash flow structure analysis
    On the basis of the cash flow statement data, cash flow structure analysis further clarify the composition of cash income and cash expenses. Cash flow structure can be divided into cash income structure, cash expenditure structure and the radio of income to expenditure structure. Cash flow structure response the proportion of cash income of the Group's business activities in total cash income and the specific composition of the business income. Cash expenditure structure refers to the proportion of business cash expenditures in current outflows, and it reflect concretely which aspect the enterprise cash use. Inflow and outflow structure analysis include inflow and outflow analysis of business activities, inflow and outflow analysis of investment activities, inflow and outflow analysis of financing activities.

(2) Net cash flow analysis
Through the net cash flow analysis, we can draw the changes of the enterprise management status: if net cash flow of the enterprises business activities is positive, net cash flow of investment activities is negative, net cash flow of financing activities is negative, it shows that the operations of the group is good, but the enterprise on one hand pay the debt before, on the other hand continue investment, so it should be ready to focus on the change of operating conditions to prevent financial conditions from deteriorating.
(3) Debt paying ability analysis
Through the analysis of corporate assets table data, we derive the enterprise's debt paying ability analysis from the current ratio, debt ratio, debt to equity ratio, debt ratio of cash flow, debt ratio of operating cash flow, the sale cash ratio.
(4) Earnings quality analysis
The main indicators of earnings quality analysis is profitable cash ratio, mainly concerning the establishment of information earnings quality analysis system of cash flow statement. This ratio reflects the ratio of net cash flow that generated from the current operating activities to net profit, namely, net profit put how many net cash flow generated by business activities as a guarantee.

165.4.3 Cash Flow Budget Management

The L Group's cash budget is not only the objectives of the Group's cash management, but also an important tool for day-to-day management control of the Group. Group set the overall goal through the budget formulation, then divide and decompose it as the objectives of subordinate members enterprise. By monitoring the budget execution of the subordinate enterprises, the administrative department of the Group, find out the difference between the actual performance results and budget goals and analyze the reasons, then correct them timely to strengthen Group's day-to-day management control (Meng 2001).

The establishment of cash budget uses initiative prepared of top-down, bottom-up, up and down combined. After done, it would be the basic norm of production and management operation, and achieve limited control in the implementation process (Luo et al. 2009).

165.4.4 Cash Flow Operation Management

Through analyzing the possibility of various factors that influence the cash flow, L Group cash flow operation management uniformly plan and schedule significant cash payment activities of group, so that the group cash management can achieve "budget well, scheduling fast, control tighter, pull quickly" (Weygandt et al. 1993).

The basic principle of the Group's cash flow operation management is based on the cash budget. Through managing and controlling cash inflow and outflow, use the tools of investment and financing management to adjust the imbalance of cash flow and achieve the overall balance and stability of cash flow.

Through the establishment of operational cash flow dynamic decision model, enterprises draw the flow of cash flow movements during a certain future, forecast and plan major cash payments by the likelihood of the various cash flow elements in the budget period, resulting ensure the balance of the cash flow management in macro, and realize the prospective of cash flow management in the microscopic, in order to better carry out the strategic planning, investment and financing decisions around the enterprise operation and investment and financing activities.

165.4.5 Cash Flow Risk Control

Cash flow risk is the possibility that enterprises have suffered losses, that because an unexpected or control factors lead to the enterprise does not match the cash receipts and payments (Fama 1991). The main content of the cash flow risk is enterprise appear cash can't satisfy the payment requirements, including meet demand, tax payment enterprise loan payments, personnel salary welfare and other expenses. It also includes the case of cash flow problems, that the enterprise can not meet the payment though has sufficient cash as flow problems. Whatever business risks appear, it will have a negative impact to the enterprise, even make the group facing bankruptcy risk. So managers must accurately forecast and analyze cash flow risk to avoid enterprise loss, which is also important to the enterprise stakeholders.

165.4.6 Cash Flow Evaluation

Cash flow evaluation indicators need to be able to analyze and evaluate cash flow, liquidity, security, efficiency and growth. Through evaluating cash flow operating conditions, valuating expected cash flow management, statically evaluating cash flow management of a point, achieve to make the right judgments and decisions to enterprise's overall financial position, solvency, profitability and future development. Specifically, mainly include the following aspects of content: the liquidity analysis, obtain the ability analysis, financial flexibility analysis, earnings quality analysis.

Establishing cash flow evaluation system is to judge the Group's management performance, assess the Group's cash flow management objectives be achieved or not, and it plays a reference to the future cash flow management improvements.

165.5 Conclusion

Based on analyzing the L Group's currently cash flow management, a general pattern of the L Group's cash flow management was constructed in the paper. Through enhancing cash flow management, enterprise improve the Group's cash flow management level and the competitiveness of enterprises to achieve business objectives.

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Chapter 166
The Study of Drop and Pull Transport Mode Based on Low-Carbon Transport Organization

Hong-xiang Qi

Abstract Drop and Pull transport is the transportation organization mode which has played the important role in Low-carbon transport industry. Several pilots to implement Drop and Pull transport in Jiangsu province have achieved the positive effort. However, many aspects still need to be considered when putting the mode into practice. This paper compared the different Drop and Pull transport modes with each other. It discussed the efficiency of them from viewpoint of the theory, transport tool, management regulation, political guidance, manpower, and resource and environment protection. Based on the case study, this paper addressed the effect and advice of the application of Drop and Pull transport.

Keywords Drop and Pull transport · Low-carbon Transport · Highway · SWOT

166.1 Background

Since the 1960s, several problems such as the global warming, air pollution, water pollution and land desertification have led to the serious and terrible consequences. China met the same problems. To pursue and achieve a rapid economic growth, the mode of “high investment with low output” has led to the serious negative impact to the environment. Sustainable green economy has been promoted, in order to enhance the ability of the socio economic sustainable development, to improve the ecological environment, the efficiency of resource usage. Low-carbon economy has been one solution of implementing the green economy as well.

A research report published by the Oslo Climate and Environmental Center for International Studies at the beginning of 2009 addresses that the releasing of used

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gas is one cause of global warming (The Huaian public transport 2010). The report is noted that the world's total carbon dioxide emissions have been increased by 13 %, and the growth rate of carbon emissions from transport has been grown up to 25 % in the past 10 years. Carbon emissions from transport have been increased by 21 %. The development of low carbon transport has become the inevitable choice of "green recovery". State Council executive meeting held in the Copenhagen Climate Conference announced that the control targets, in which the carbon dioxide emissions per unit of GDP in 2020 should be decreased to 45 % compared to 2005, and appropriate statistics will be developed as a binding target, monitoring and evaluation methods. The conference stated that China should "speed up building the construction of low-carbon system", and "speed up building the formation of low-carbon green lifestyles and consumption patterns".

This article compared and analyzed the Drop and Pull transport mode carried out in the typical regions of Jiangsu Province. Scientific theory, modern technology tools, the implementation of scientific management system and work force management are discussed in the argument.

166.2 Drop and Pull Transport Organization Mode Based on the Low-Carbon Traffic

Development of efficient transport, Drop and Pull transport, multi agent transport, bulk cargo and container terminal transport should be promoted. Urban public transport, the network layout of the passenger lines and station should be optimized; the process of integration of urban and rural passenger transport should be improved; the road transport networked ticket system should be developed. The urban bus priority strategy, the low-carbon travel and energy-saving driving project should be effectively implemented.

Energy-saving measures and emission reduction of road traffic rely on the economic structure, energy structure, and social policy environment of different cities in Jiangsu Province. By now, Drop and Pull transport is an effective mode with the most extensive range of applications.

Drop and Pull transport mode includes a series of different transport measures by adopting the Drop and Pull transport technology; it is the optimized transport thinking. In general, the premise of Drop and Pull transport is the separation of trailer and tractor; under the guidance of the different transport routes and transport planning, a tractor brings more than one trailer and conveys them from one point to another.

Drop and Pull transport contains several types of modes:

A *Single loading and unloading nodes*: This transport mode addresses that the transport tool (such as the tractors and trains) travels between one loading and one unloading nodes, which is called a transport system. There are a number of tractors settled in the system, and the transport tools carry out the drop and pull work between the two points. For example:

The Drop and Pull transport operations are carried out in the loading or unloading nodes. In this case, there will be drop and pull operations only in the loading or unloading node.

The Drop and Pull transport are carried out in both the loading and unloading nodes. In this case, there will be drop and pull operations in the loading and unloading nodes. It is suitable for the back-and-force transport of short distance and large amount of cargos, in which the loading and unloading nodes are fixed.

B *Cycle Drop and Pull transport*: The cycle Drop and Pull transport are carried out in a closed cycle transport line, and several loading and unloading nodes are located among the transport line. There are a number of containers or trailers in each loading and unloading point. The arrival containers cargos will be firstly unloaded from the tractors, and then the prepared containers or cargoes will be loaded onto the tractors. This can be done in each loading and unloading nodes.

C *Multi points and Single line Drop and Pull transport*: This transport mode requires that the transport tool load the cargos under the planned sequence at the starting location. The principle such as "cargos unloaded lately should be loaded in front" should be followed. This mode is suitable for the transport system with multi loading and unloading transport nodes (Kenneth 1997).

D *Multi lines linked with one node*: In this case, several transport lines will be linked with one node (The cross node), and the Drop and Pull transport operation will be finished by sequence. The cross node will prepare the planed cargos before the transport tools arrive. The tractor will unload and then load the prepared cargos when it arrives at each node. This mode it suitable for the multi loading corresponding with single unloading process as well as the multi unloading corresponding with single loading process.

Drop and Pull transport has several merits: reduce the waiting time of loading and unloading tractor, enhance the turnover efficiency, improving the transport efficiency and labor productivity; save cargo storage spaces and reduce the logistics costs; support the organizing of multi mode transport; reduce the invalid vehicle transport, reduce energy consumption and emissions; promote the development of an integrated transport (Office of Freight Management and Operation 2007).

Drop and Pull transport has been widely promoted and used in the international arena, and has become very common in modern transportation organizations. The development of Drop and Pull transport would be of great significance in reducing logistics costs, and promoting the energy reduction, improving the overall quality of economic operation (Yang 2009).

There are several aspects of transport which need to be considered:

(1) Transport equipment and technologies: The tractor and trailers can be separated, so the multi location transportation by one truck can be handled.
(2) Mode of transport: Drop and Pull transport relies on the resources of road transport, the ability of the road passage.

(3) Transport individuals: The terminal unit of the Drop and Pull transport is individual transport vehicles, driver of tractor and loading and unloading persons which would operate the tool.
(4) The platforms: To promote the Drop and Pull transport, facilities such as logistic park or plant need to be established with a moderate scale, function, and positioning and maintenance team.
(5) Business modes: The types of creative transportation mode would be value-added, such as one vehicle with multi trailers, multi cars in three sections and so on.
(6) Policies: The policy of Drop and Pull transport could fully fill the logistics parks, logistics centers and the rural logistics station. For example: building a logistics center, settling down the passage right and cutting the tolls, all of these would affect the efficiency of several logistics nodes in direct or indirect way.

166.3 Case Studies

As an efficient energy saving mode, several pilots of Drop and Pull transport have achieved the great success (Wen 2011). For example (Lin 2011):

A Suzhou
Suzhou International Container Transport Co., Ltd implements the Drop and Pull transport mainly from the following aspects:

(1) Fees policy to support the Drop and Pull transport
Based on the market investigation, the measures of trailer road maintenance, cargo surcharge, traffic insurance protection charge were conducted. Road maintenance mode reference to which of the Fujian mode, the collection of the main vehicle, tractor or trailer were adjusted, and the trailer is free for road maintenance fee.
(2) Improve the organization.
Container transport and roads rapid freight combined the advanced product and transport equipment. Drop and Pull transport is the main organization of technical.
(3) To guide logistics enterprises to carry out Drop and Pull transport.
Based on the policy, a number of large-scale transport enterprises were organized to carry out the work of Drop and Pull transport. The operability of transport was improved through the actual operation. Some key areas such as IT products, dangerous goods, biological products, high value-added supply market, can fully make use of the advantages of Drop and Pull transport. (Motor Transport Group Co., Ltd of Suzhou 2011)
(4) To simplify the management measures.
The documents of Drop and Pull transport vehicles should be adjusted for

the annual inspection, the age and other management issues. It is recommended to simplify the handover process of documents with tractor and trailer. The tractor can be detected separately from the trailer. It is appropriate to reduce the annual number of detections of the trailer; trailer service detection should be done once a year.

B Nantong
Nantong Transportation and Logistics Group business implements the following Drop and Pull transport modes (Liu 2011):
Organization of vehicles: Nantong Transportation and logistics group started the Drop and Pull transportation in 2008. The number of tractors and trailers has increased up to 95 and 200, and the branch transport companies are organizing the special vehicles. The total amount of tractors is 125, normal amount of normal trailer 205. The amount of container trailer is 90. The ratio of number of tractor and trailer is 1:2.36, similar to the proportion in North America, Western Europe and developed countries.

The special transportation lines up with Drop and Pull transport such as Nantong–Shanghai line, Nantong–Ningbo line, Nantong–Qingdao line, Nantong–Beijing line, Nantong–Suzhou line, Nantong–Changzhou line and Nantong–Yangzhou line have been carried out. The transport modes of door-to-door and 24-hour-service have been provided (Xiang and Zheng 2009).

In future, the Nantong Transportation and Logistics Group will spend 200 million RMB planning and constructing a logistics park, which covers a range of 14,400 square meters with modern warehouse and ancillary facilities, in order to provide the customers with warehouse, transportation, distribution and processing services.

166.4 The Analysis of Drop and Pull Transport Based on the Low-Carbon Transport Mode

SWOT analysis was adapted to analysis the pilot Drop and Pull transport (Lin 2011):

A *Advantages*: The utilization of single vehicle in the pilot companies has been increased from 60 to 75 %. Energy consumption was decreased by 20 %.
Drop and Pull transport reduces the cost of logistics enterprises in terms of expanding. The procurement of advanced positioning equipment, the reduction of circuitous transport, repeated transport and convective transport enhance the strength of the logistics efficiency.
The number of tractors is reduced as well as the emissions, fuel consumption, which has played a leading role in reduction of energy emissions (Logistics Group Co., Ltd Nanjing distant 2011).

The knowledge and ability of employees are improved with the systematical test of theory and operation. The impact of multi Region transportation was displayed. By promoting the multi line transport in different regions, significant benefits were showed among different cities.

B *Disadvantages*: Since the Drop and Pull transport refers to many different aspects such as transportation, traffic control, highway maintenance, the pilot companies tried the drop and pull policies at the beginning. However, the policies could take good effort only within the ranges of cities, the "point-to-point transport cannot play the role of the network transport".

The cost of implementing the Drop and Pull transport in different regions is different, which may lead to the obstacles during the combination of two systems. For example, the cost to implement the Drop and Pull transport mode in Yangzhou region is more than that in Nanjing, because the traffic base and highway network of transport is weaker in Yangzhou.

Procurement and the elimination of the vehicles would cost a lot in the Drop and Pull transport. The lack of infrastructure and equipments is common problem. Some of the energy-saving vehicles could not be used in the drop and pull mode. Some vehicles could not be used for the purpose of multi agent transportation. Thus, the pilot companies have to spend more money buying the valid tractors and trailers. Since the energy-saving emission vehicles may not have the ability to pull transport. Meanwhile, there are many transport tools which cannot play the role in Drop and Pull transport in the original places, and have to be eliminated without the full usage. That is also a big waste of recourse.

Therefore, if the government can focus on arranging and reusing the eliminated vehicles, and re-assign the vehicle recourse for different cities based on different drop and pull modes, the energy and cost waste could be efficiently avoided.

C *Opportunity*: Drop and Pull Transport is a transportation mode with strongly onsite and offsite control, which is strongly needed in company and government. The transport supporting equipments can provide enough supporting only with the good planned schedule and correct information. Therefore, in the process of promoting the technology model, company and government will be able to improve the ability of their information control and logistics management.

By promoting the Drop and Pull transport, the policies, information system, the standard of different cities and companies can be arranged, which will enhance the transport effect in the whole system. It is good to achieve "seamless transport".

The development of Drop and Pull transport can also drive the promotion of a series of logistics IT. Logistics solutions can be more professional and supportable; logistics equipments can be developed and produced. The logistics industry can therefore be promoted.

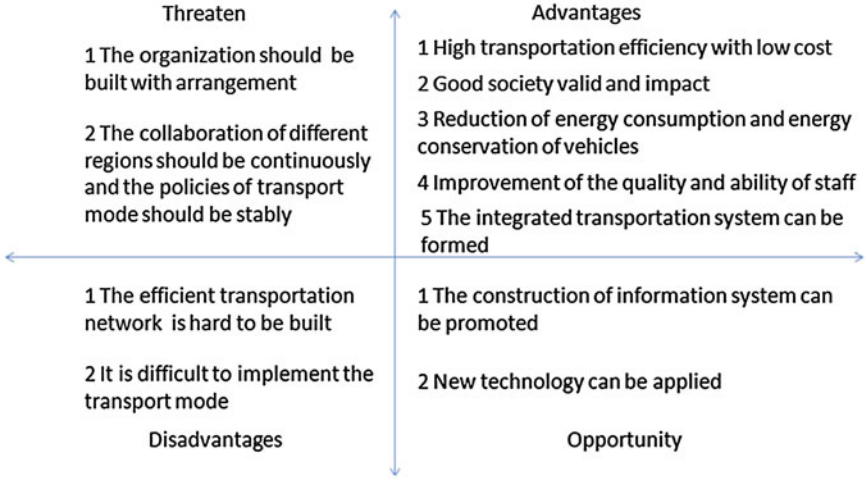

Fig. 166.1 SWOT analysis of drop and pull transport

D *Risk*: The promotion of the Drop and Pull transport by equipment, technical extension, management and marketing should be gradually done. Transport modes should be integrated. The process of implementation of work should be well planned, in order to reduce the cost of transport and the operation risk.
Drop and Pull transport should be implemented under a stable policy environment. If the regulations and requirements changes from time to time, the construction and management work are difficult to be promoted.
Drop and Pull transport can be analyzed by SWOT approach, which is shown in Fig. 166.1.
Based on the Cross-analysis of the Drop and Pull transport market, the basic transport enterprises in the province can be divided into four categories. Compared with the above four categories, economic strategies of Drop and Pull transport can be summed up (Table 166.1).
By analyzing the four types of strategies, there are some solutions for the Drop and Pull transport mode, which are showed in Fig. 166.2.

Table 166.1 The management strategy based on SWOT

Strategies of SWOT		Inside	
		Strength (S)	Weakness (W)
Outside	Opportunity (O)	The improvement strategy	The turning strategy
	Threaten (T)	Pluralistic strategy	Recovery strategy

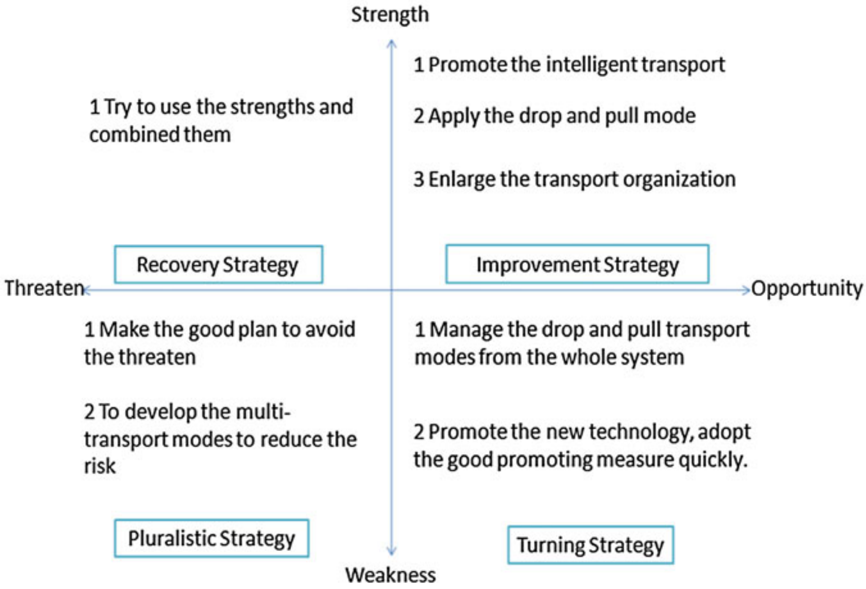

Fig. 166.2 Drop and pull transport enterprise operation analysis strategies

166.5 Conclusion

This paper studied the Drop and Pull transport organizational mode based on low-carbon transport, parts of the pilot were conducted with appropriate comparison and analysis, the advantages and risks of implementing a Drop and Pull transport was finally summed up. Government and companies could make the fully analysis on local economy, policy, resources and environment and combination before carrying out this mode. The progress of this mode should be carefully discussed and proved by the consideration of the surround area; the promoting of transport scheme should be logically implemented. When policies and mode environment are stable and protective, the Drop and Pull transport in the individual enterprises can be independently explored. The judgment, analysis and comparison of Drop and Pull transport in different companies can be carried out in future.

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Chapter 167
Absolute Delay Calibration of Antenna for Inter-Satellite Communication

Xiao-zhun Cui, Hai-qing Dong, Cheng-bin Kang and Tian-xiong Liu

Abstract The number of antenna for inter-satellite communication of distributed spacecrafts is larger than three. All the antennas have the same property. Three antennas are taken to form into three groups and each group consists of two antennas. For each group, transmitter transmits ranging signal via a testing antenna, receiver receives the ranging signal via another testing antenna. The delay from transmitter to receiver can be measured. Absolute delay of the three antennas can be obtained after data processing. The proposed method is easy to realize and needn't extra calibration antennas. Using the inter-satellite communication signal as testing signal, the calibration results can represent the real delay of antennas for inter-satellite communication.

Keywords Absolute delay · Antenna · Calibration · Inter-satellite communication

167.1 Introduction

For the formation of distributed spacecrafts, the spacecrafts use inter-satellite communication equipment to transmit and receive PRN (pseudorandom noise) code modulation signal to range the space between each other (Main et al. 2004;

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Stadter et al. 2002; Luba et al. 2005). The ranging precision is the key parameter for the spacecraft constellation. Only by subtracting the delay caused by the inter-satellite communication equipment, the real range between two spacecrafts can be obtained. The calibration precision of the inter-satellite communication equipment is affected the range precision between spacecrafts. Because the antenna is a key component of inter-satellite communication equipment, the absolute delay of antennas is the key parameter. The calibration precision of antennas is affected the range precision between spacecrafts.

Huag and Qin (2007) proposed a test equipment scheme for antenna delay measurement using calibration transponder and calibration antenna, the main defect is that calibration precision of the test equipment is affected the antenna delay measurement seriously. IEEE Std (149-1979) described a delay measurement technique which is based on the phase measurement of a single-carrier. Levitas and Ponomarev (1996) has been developed an antenna measurement method in time domain using a pulse generator and sampling oscilloscope. Absolution delay calibration technique using Vector Signal Analyzer (VSA) has been developed in Lestari et al. (2005), Wu et al. (2009) and is also introduced and implemented by the International Research Center for Telecommunication and Rader (IRCTR) (Lestari 2003). As the latest trend in frequency band of inter-satellite communication is ka band, V band and millimeter wave band (Lin et al. 2010; Ranwa et al. 2009; Choung 2005), the standard antenna for calibration is difficult to made. In order to meet the requirements of antenna calibration in far-field region, the test cable or waveguide is very long. The stability and precision of the delay caused by transmission line will be another problem. The most important problem of the above-mentioned method is that the calibration results are group delay and not the same as the delay caused by a PRN modulation signal transferring.

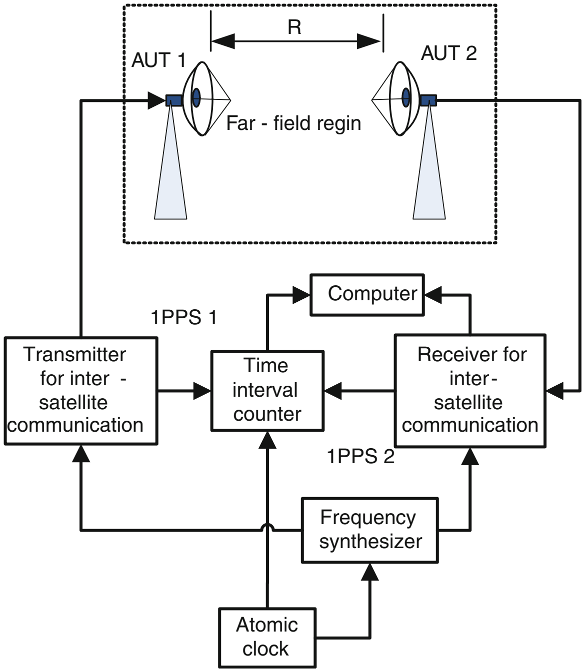
The proposed technique use the inter-satellite communication signal as the test source, the calibration result can represent the real delay of antenna for inter-satellite communication.

Test facility description is provided in Sect. 167.2. Section 167.3 describes the absolute delay calibration technique and procedure of antennas for inter-satellite communication. The error of calibration is analyzed in Sect. 167.4. The verification of the proposed delay calibration technique is depicted in Sect. 167.5. The conclusion of the proposed technique is discussed in Sect. 167.6.

167.2 System Overview

A block diagram of the absolute delay calibration of antenna for inter-satellite communication is shown in Fig. 167.1.

Fig. 167.1 Block of the calibration system



167.2.1 Atomic Clock

As far as possible to low the effect caused by the test system frequency reference, the output of atomic clock is used as the system frequency reference because of the high stability and high frequency accuracy. As hydrogen masers are the most stable frequency sources readily available and have been applied for space application (Beard et al. 2002; Mattioni et al. 2004; Berthoud et al. 2003), a hydrogen maser is used as the system frequency reference. Typical phase noise of hydrogen maser for increasing frequency offsets from the carrier frequency is listed in Table 167.1 (Schweda et al. 2007).

Table 167.1 Typical phase noise of hydrogen maser (Schweda et al. 2007)

Frequency offset (Hz)	Phase noise (dBc/Hz)
1	−89
10	−101
100	−113
1 k	−130
10 k	−152

167.2.2 Frequency Synthesizer

The frequency synthesizer generates the basic frequency that feed into the transmitter and receiver as the local reference frequency of each module.

167.2.3 Transmitter and AUT1

Transmitter exports PRN modulation signal and then take out directly to an antenna under test (AUT) which name as AUT1. Simultaneously, transmitter exports 1PPS (1 pulse per second) signal which name as 1PPS1.

167.2.4 Receiver and AUT2

The signal emerging from another AUT which name as AUT2 is feed into the receiver for inter-satellite communication. The receiver generates another 1PPS naming as 1PPS2.

167.2.5 Time Interval Counter

Time interval counter measures the interval between 1PPS1 and 1PPS2. The reference of the time interval counter is atomic clock and the time resolution of the time interval counter is better than 0.01 ns.

AUT1 and AUT2 aimed at each other during measure. After reading the measure result from time interval counter and receiver, computer provides the combined delay of the whole link from transmitter to receiver. Delay of calibration system is shown in Fig. 167.2.

The combined delay T_{com} calculated out by computer is:

$$T_{com} = T_{PPS} + T_{pd}, \tag{167.1}$$

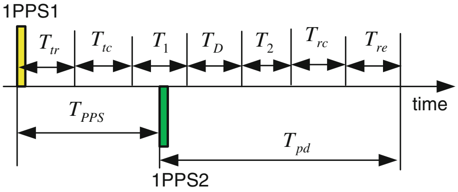


Fig. 167.2 Delay of calibration system

where T_{PPS} is the interval between the 1PPS1 and 1PPS2, assuring that the 1PPS2 lagging 1PPS1. T_{pd} is the pseudo-range providing from receiver.

The absolute delay of the test system can be express as:

$$T_z = T_{tr} + T_{tc} + T_{rc} + T_{re}, \tag{167.2}$$

where T_{tr} is absolute delay of transmitter; T_{tc} is absolute delay of transmission line from transmitter to AUT1; T_{rc} is absolute delay of transmission line from AUT2 to receiver; T_{re} is absolute delay of receiver.

In theory, the combined delay of the whole link from transmitter to receiver is:

$$T_{com} = T_z + T_D + (T_1 + T_2), \tag{167.3}$$

where T_D is absolute delay of free space between AUT1 and AUT2; T_1 is absolute delay of AUT1; T_2 is absolute delay of AUT2.

167.3 Calibration Technique

There are several antennas of same property for inter-satellite communication of spacecraft constellation. The number of antennas is larger than 3. The antennas for inter-satellite communication are passive devices and the delay for transmitting and receiving signal are the same. Choosing three antennas to measure, AUTs are named as AUT1, AUT2 and AUT3 respectively.

The first step is the delay calibration of the test system. The output of the transmitter connected to receiver directly with cable and attenuator. The combined delay T_{Z1} of link from the transmitter to receiver is measured. The combined delay T_{Z2} caused by cable and attenuator can be calibrated with VSA. So the absolute delay of the test system is:

$$T_Z = T_{Z1} - T_{Z2}, \tag{167.4}$$

The space between two AUTs satisfies the following inequality.

$$R \geq 2D^2/\lambda, \tag{167.5}$$

where λ is the wave length of central frequency and D is the diameter of the AUT. The absolute delay of free space between the two AUT is:

$$T_D = c/R, \tag{167.6}$$

where c is the light velocity in free space.

AUT1 acts as the transmitting antenna and AUT2 acts as the receiving antenna. The sum of AUT1 and ATU2 delay is:

$$T_1 + T_2 = T_{C1} - T_Z - T_D, \tag{167.7}$$

where T_{C1} is combined delay of the whole link of transceiver with AUT1 and AUT2.

AUT3 acts as the transmitting antenna and AUT2 acts as the receiving antenna. The sum of AUT3 and ATU2 delay is:

$$T_3 + T_2 = T_{C2} - T_Z - T_D, \tag{167.8}$$

where T_{C2} is the combined delay of the whole link of transceiver with AUT3 and AUT2.

AUT3 acts as the transmitting antenna and AUT1 acts as the receiving antenna. The sum of AUT3 and ATU1 delay is:

$$T_3 + T_1 = T_{C3} - T_Z - T_D, \tag{167.9}$$

where T_{C3} is the combined delay of the whole link of transceiver with AUT3 and AUT1.

With the above equations, the absolute delay of AUT1, AUT2 and AUT3 can be calculated out as following:

$$T_1 = \frac{1}{2}(T_{C1} - T_{C2} + T_{C3} - T_Z - T_D), \tag{167.10}$$

$$T_2 = \frac{1}{2}(T_{C1} + T_{C2} - T_{C3} - T_Z - T_D), \tag{167.11}$$

$$T_3 = \frac{1}{2}(-T_{C1} + T_{C2} + T_{C3} - T_Z - T_D), \tag{167.12}$$

For measuring a new AUT naming as AUTn, AUT1, AUT2 and AUT3 is selected randomly. Assuming AUT1 is chosen to act as the transmitting antenna and AUTn acts as the receiving antenna, the sum of AUT3 and ATU1 delay is:

$$T_n + T_1 = T_{Cn} - T_Z - T_D, \tag{167.13}$$

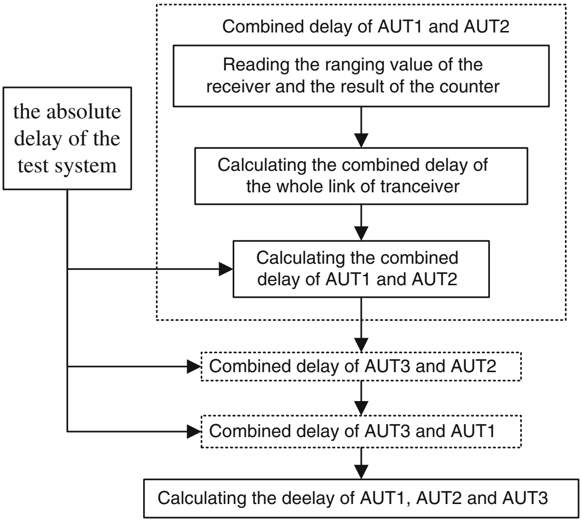
where T_{Cn} is combined delay for AUTn and AUT1.

The absolute delay of AUTn is:

$$T_n = T_{Cn} - T_1 - T_Z - T_D, . \tag{167.14}$$

The flow chart of delay calibration of antenna for inter-satellite communication is shown in Fig. 167.3.

Fig. 167.3 Flow chart of delay calibration of antennas



167.4 Error Analysis

The error of the calibration is below.

(1) The calibration of the space between the transmitting antenna and receiving antenna. The range calibration is done by laser ranging system. The rang calibration error is less than 0.1 ns (Wang et al. 2010).
(2) The calibrating error of the test cables and attenuator. Adopting VSA, the error is less than 0.1 ns;
(3) The influence of circumstance temperature and connector of instrument. The error is less than 0.1 ns.
(4) The ranging error caused by receiver. As using the atomic clock as frequency reference, the ranging error of the narrow band receiver is less than 0.1 ns.

In summarization, total error of the calibration system is less than 0.4 ns.

167.5 Verification

A block of the verification of the calibration method is shown in Fig. 167.4. The error of the proposed calibration method is the same as the measure error of the verification system. The absolute delay is obtained after measuring the combined delay of the whole link of transceiver.

The transmitter exports the PRN ranging signal continuously. The computer provides combined delay of the whole link of transceiver every second. Averaging 60 combined delay results per minutes, the average absolute curve of calibrating

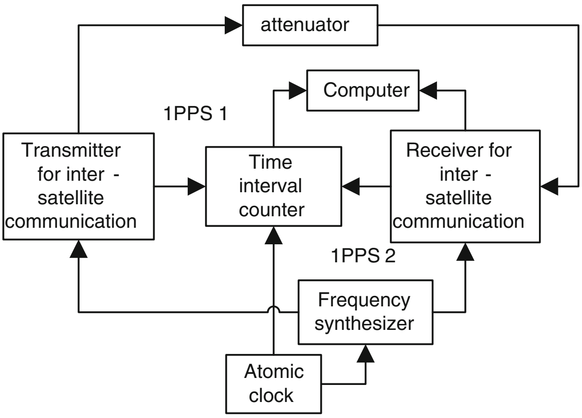


Fig. 167.4 Verification of the calibration

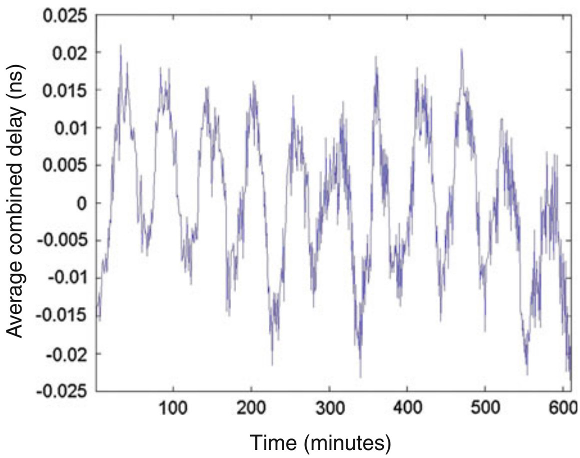


Fig. 167.5 Average absolute curve of calibrating system for 10 h

system for 10 h is shown in Fig. 167.5. The fluctuation of the average absolute for 10 h is 0.045 ns. Stand variance is computed per 60 number. Stand variance curve of calibrating system for 10 h is shown in Fig. 167.6. The uncertainty is 0.0229 ns (2σ). The verification results show that the error of the calibration system is less than 0.1 ns and the uncertainty is less than 0.023 with averaging.

167.6 Conclusion

The proposed absolute delay calibration technique needs not special calibration antenna. The testing signal is the inter-satellite communication signal and the test results can denote the real delay of antenna for inter-satellite communication. The calibration precession is dominated by the property of the receiver. Because the

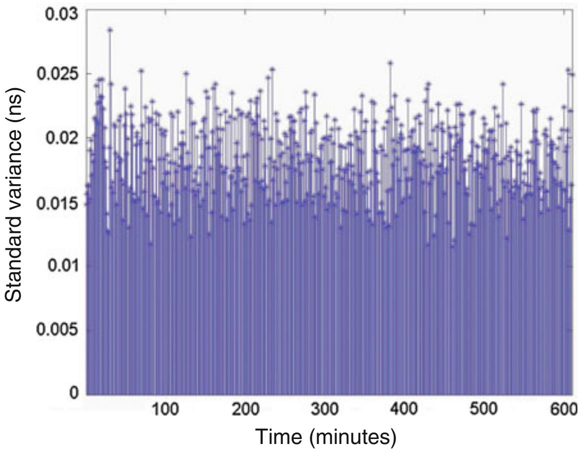


Fig. 167.6 Stand variance curve of calibrating system for 10 h

calibration results is educe from the combined delay of the signal from transmitter to receiver, the frequency band of calibration system is high and wide. The calibration system adapts to the band assigned for inter-satellite communication by the International telecommunication union (ITU).

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Chapter 168
An Intelligent Public Transportation Dispatching System Based on MAS

Xiang-hua Wang, Te-fang Cheng and Bi-ming Zhang

Abstract This paper is focused on the description of an Intelligent Public Transportation Dispatching System (IPTDS) Based on Multi-Agent System (MAS). As a hot-spot in the field of the computer and distributed artificial intelligence, MAS has been paid more and more attention in recent years. Urban public transportation system has the characteristics of complex structure, concurrent processing and diversity, so it is difficult to solve the dispatching problem effectively. Therefore, this paper applies MAS technology to the solution to the public transportation dispatching problem. In this paper, firstly, a system framework of IPTDS is designed, then a MAS model is abstracted from the IPTDS system framework, at last, the function and structure of the Agents in the system is described.

Keywords Agent · MAS · AI · APTS · IPTDS

168.1 Introduction

With the urbanization of China, traffic congestion has been increasing in the large and medium-sized cities. Traffic congestion has reduced the efficiency of transportation and increased travel time, air pollution, and fuel consumption. The effective solution to these problems is to develop Advanced Public Transportation System (APTS) (Yang 2004; Lu et al. 2004). APTS which is based on global positioning technology, wireless communication technology, geographic information technology and computer technology, realizes the visualization of intelligent

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bus dispatching bus operation, improves the information service for passenger, promotes intelligence traffic and helps build a low carbon city (Zhang 2001; Zhu et al. 2002). However, the urban public transportation dispatching system in China is still with a traditional manual operation, in which the dispatcher can only know the situation on the start and the terminal stations, and the driver on the line only knows his own vehicle's situation, the dispatcher and the driver cannot deal with the problems timely when some accidents occur, such as a temporary traffic jam, vehicle equipment failure, and other problem comes up, such as passengers cannot get on buses or need to wait for a long time because of the late arrival of buses while several buses arrive at one time sometimes (Wang et al. 2006; Ao 2010; Yang 2002; Guan 2002). As a result passengers always complain about the poor performance of public transportation system while the bus companies grumble about the low profits (Zheng and Yan 2005). Therefore, it's crucial to improve the efficiency of the public transportation dispatching operation and to ensure the satisfaction of public demand as well as economic benefits of the bus companies. In order to solve the problems, this paper puts forward a new IPTDS based on MAS.

168.2 Agent and MAS

With the rapid development of computer technology, network technology, communication technology, Agent and MAS has become an important research field of Artificial Intelligence (AI) and computer science. MAS has a high level of self-governing and adaptability, can adapt to deal with unpredictable, dynamically changing environments, which embodies its human social intelligence (Wooldridge 2009; Liu 2001). Agent-based systems are becoming one of the most important computer technologies, holding out many promises for solving real-world problems.

Therefore, more and more researchers began its theoretical and applied research. At present, MAS has been widely used in traffic control, e-commerce, multi-robot systems, military, and many other areas.

168.2.1 Agent

Agent is a computational system that can acquire sensory data from its environment and decide by itself how to relate the external stimulus to its behaviors in order to attain certain goals. Responding to different stimuli received from its task environment, the Agent may select and exhibit different behavioral patterns. The behavioral patterns may be carefully predefined or dynamically acquired by the agent based on some learning and adaptation mechanisms (Foundation for Intelligent physical Agents, FIPA Application specifications; Foundation for Intelligent physical Agents, FIPA abstract architecture specification).

Fig. 168.1 Agent in environment

Figure 168.1 shows: the Agent can accept the input from the environment and output the corresponding action, and the Agent can continue to amend his behavior in interactive. This interactive activity is Agent learning mechanism. Because of this mechanism, Agent can adapt the dynamic change environmental condition. The process of Agent's learning behavior can be expressed in the following formula:

$$\forall \varepsilon, \exists \beta \subseteq \{\tau\}, \varepsilon(A, \beta) \Rightarrow (N, \upsilon) \tag{168.1}$$

$$Z(t) = \varepsilon(t-1) \oplus Z(t-1) \tag{168.2}$$

where, A is an Agent; τ, the behaviors set of Agent; β, the behavior that current selected; ε, the current environment condition; υ, the evaluation criteria; N, Constraint conditions; $\varepsilon(A, \beta)$, evaluation after A completes behavior β; t, time; $Z(t)$, Knowledge or experience at time t; operator $\Rightarrow$, satisfy; operator $\oplus$, update.

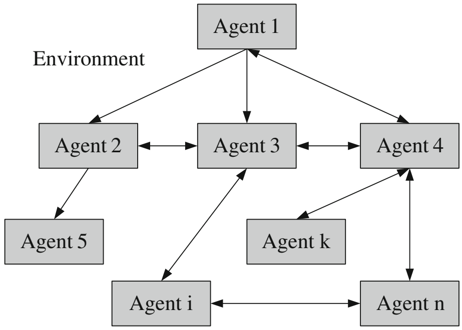
168.2.2 MAS

MAS is a collection composed of many Agents which carry on information sharing, mutual correspond and the coordination of and control of each other. Each Agent can have different information processing and problem-solving ability. MAS can form a homogeneous or heterogeneous system, and its calculation process may be asynchronous or parallel. MAS is better than the single agent, possesses higher intelligence and has a stronger ability of problem solving, so it can deal with some tasks that single Agent cannot complete (Adler et al. 2005; Lu and Song 2007). At present, MAS has become a research hot-spot in the fields of artificial intelligence, automatic control and computer science. Figure 168.2 is a MAS structure.

168.3 Design of IPTDS

Urban public transportation is a complex dynamic system, which is composed of people and vehicles and other components, which is affected by its openness and

Fig. 168.2 A MAS structure



random and many other uncertain factors. According to the characteristics of public transportation dispatching operation environment, the system framework chart is designed as shown in Fig. 168.3.

IPTDS mainly consists of the following sub-systems.

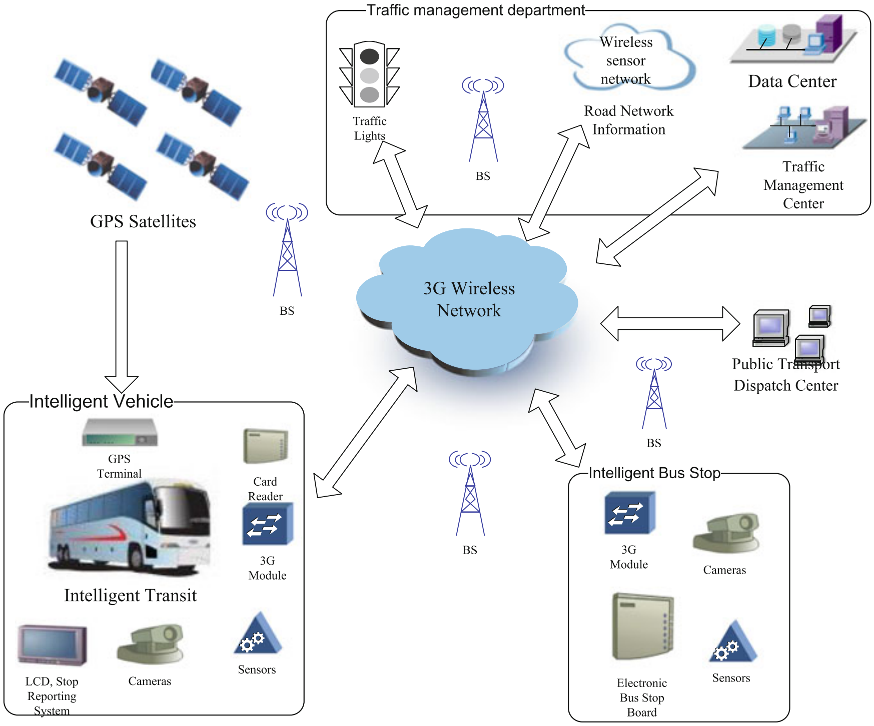


Fig. 168.3 System framework of IPTDS

168.3.1 GPS Navigation System

It mainly includes the GPS module, the 3G module, display module, and Geography Information System—Transportation (GIS-T) in the dispatch center. The 3G module can transmit the location information collected by the GPS module to the bus dispatch center, and the GIS-T system can dynamically display the operational status of the vehicle, such as its location, speed, direction, time, and so on.

168.3.2 3G Wireless Network Information Support Platform

3G, namely the third generation of mobile communication network technology, refers to support high speed data transmission in cellular mobile communications technology. 3G network service can transmit voice and data information simultaneously. Due to the high data transmission rates and high mobility of 3G network, the information support platform of the entire public transport dispatching system was built on 3G wireless network platform.

168.3.3 Intelligent Public Transport Vehicles System

It mainly includes the GPS module, the 3G module, cameras, electronic display monitors, automatic announce stops system, IC card readers, sensors, and so on. It can transmit the location information collected by the GPS module to the bus dispatch center, and the dispatch center GIS system can dynamically display the operational status of the vehicle, such as its location, speed, direction and time. Cameras are used to record driving conditions, such as road congestion and the information about whether the buses are crowded or not.

168.3.4 Intelligent Bus Stop System

The electronic stop Board can accept the information from the public transportation dispatch center, and display the estimated time of the arrival of the next bus, and the status of the carriage overcrowding in the bus; It can provide passengers with inquiry service; In addition, it can be used to publish the government notification, traffic information, weather information, as well as commercial advertisement and other convenience services. The station cameras are mainly used to record the passengers crowding degree in the station and the road traffic information. The station sensors are used to measure temperature, humidity, wind direction and other data, and all these information are displayed on the electronic stop board.

168.3.5 Intelligent Public Transportation Dispatching Center

It can dispatch the public transportation vehicles automatically according to the season, weather and climate, time, holiday, road network, traffic control information, the number of passengers at bus stops, the number of passengers in buses and so on.

168.4 Implement of IPTDS

168.4.1 MAS Abstract Model of IPTDS

IPTDS is a distributed system and the public transportation dispatching is a NP-problem. At present, the researches of public transportation dispatching are mostly based on static model (Wang et al. 2006; Ao 2010), is not suitable for the complex and dynamic environment of public transportation. Therefore, this paper designs a IPTDS based on MAS to handle the public transportation dispatching problem. With the design method of MAS, entities in IPTDS can be abstracted into Agents, and each Agent has respective intelligence and can feel the change of external environment and react, and cooperate with other Agents to complete the transportation task.

In Fig. 168.4. Data Interface Agent is responsible for data communication; Stop Agents are responsible for data acquisition, bulletin board and passenger query service; Dispatch Agent and Bus Agent are responsible for bus dispatching in real-time.

168.4.2 Structure of Dispatching Agent

Dispatching agent is one of the key models of IPTDS and responsible for bus scheduling tasks. It can obtain the real-time traffic information from the detectors, and carry on the reaction and decision-making and departure control, and register new Bus Agent in the system, so that it can carry on the real-time control to the vehicles on the bus route.

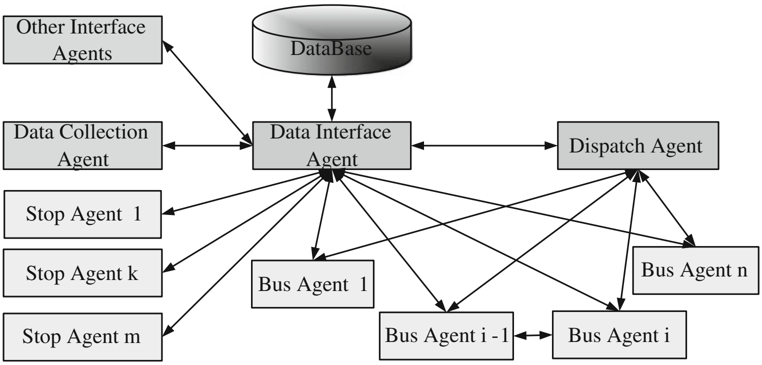
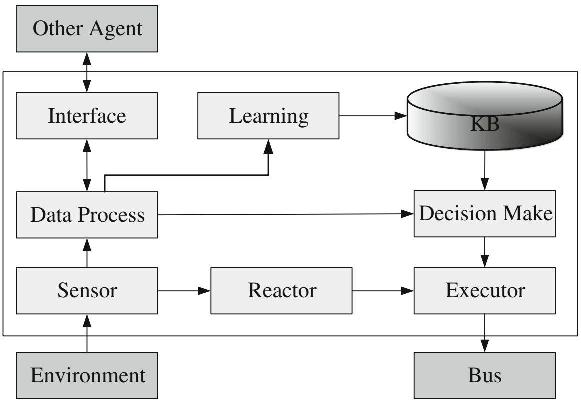


Fig. 168.4 MAS model of IPTDS

The structure of dispatching Agent shown in Fig. 168.5, the mainly functions of each part are as follows:

(1) Sensor unit: to receive the information of external traffic environment.
(2) Reactor unit: to respond swiftly to emergencies in the reaction module.
(3) Data process unit: to preprocess the data, to delete data that do not meet the requirements and to establish the optimal model of the dispatching model according to the relevant information.
(4) Decision-making unit: to determine the current control strategy according to the knowledge base and scheduling model.
(5) Executor unit: to control the vehicles in real-time and dynamically according to the control strategy.
(6) Learning unit: to update, supplement or delete the knowledge in knowledge base.
(7) Interface unit: to communicate with other modules.

Fig. 168.5 Structure of dispatching agent



168.4.3 Structure of Bus Agent

Bus Agent is an intelligent entity abstracted from the bus driving behavior on the actual bus lines, can obtain the information of the external environments automatically, and can possess their own knowledge and decision-making ability, and can adjust their driving behavior according to surrounding traffic conditions in real time. For example: According to passenger crowding of the bus in front, the number of waiting passengers at the stop in front, and the distance between bus in front, Bus Agent decides to overtake the bus ahead or not (Fig. 168.6).

Bus Agent includes:

(1) Vehicle characteristics: includes vehicle basic physical properties, such as vehicle number, passenger capacity, and so on.
(2) Driving plan: mainly refers to some of the characteristics of the current bus route, such as driving schedules, and so on.
(3) Environmental perception unit: feels the changes in the external environment, similar to the various sensors installed in the bus.
(4) Execution unit: carry on the strategy for the next step driving behavior.
(5) Knowledge base: the basis of agent decision-making, including knowledge, fact or control rules.
(6) Decision-making and intelligent control unit: the core part of the Bus Agent, including appropriate strategies and control unit, such as free driving strategy, car-following strategy, overtaking driving strategy, etc.

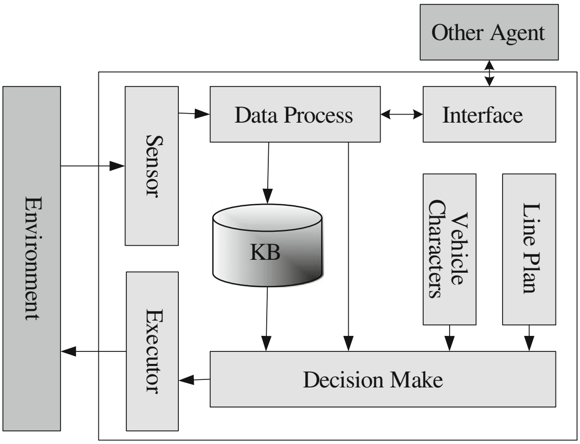


Fig. 168.6 Structure of bus agent

168.5 Conclusion

Transportation system is a dynamic and complex system, which consists of roads, vehicles, traffic facilities and human. The development of MAS theory has provided a new thought and method for the transportation system research, which has attracted many researchers and scholars' attention. At present, it has become a research hot-spot in the field of transportation that MAS technology is applied to intelligent transportation system. The application of MAS technology to dynamic bus scheduling is an innovation of this study. This system has memory and learning ability, can solve the problem of the representation and management of the scheduling model. Practice shows that it has a higher accuracy and flexibility than traditional public transport dispatching system, and it can adapt to the complex and changing transportation dispatching environment well.

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Chapter 169
Dynamic Condition-Based Maintenance Scheduling Using Bee Colony Algorithm (BCA)

Zhenyou Zhang and Kesheng Wang

Abstract Unexpected failure causes tremendous losses in economy and production, and may cause hazard of staff and equipment in manufacturing plant. A Condition-Based Maintenance (CBM) strategy can reduce these losses and guarantee the safety of personnel and machines by maintaining or repairing equipment just before failure. This paper presents a condition-based predictive maintenance model in system level for manufacturing industries which finally calculating the whole profit. Bee Colony Algorithm (BCA) is applied to find the maximum whole profit based on this model, and meanwhile maximizing availability. The optimal dynamic condition-based predictive maintenance scheduling could be achieved with reducing maintenance productivity, avoiding catastrophic losses, and prolong equipment service life according to the condition of the machine. The case study shows its effectiveness and efficiency of the proposed methodology.

Keywords Bee Colony Algorithm (BCA) · Condition-based maintenance · Maintenance model

169.1 Introduction

The range of maintenance cost is from 15 % for manufacturing companies and 40 % for iron and steel industry of the whole cost of manufactured parts and machines (Mobley 2002). The corresponding cost in United Stated is more than

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200 billion dollars every year (Chu et al. 1998). This shows the significance of maintenance in the viewpoint of economy.

Generally, there are three different types of maintenance strategies. The first one is called Corrective Maintenance (CM) which is similar to repair work, is undertaken after a breakdown or when obvious failure has been located. The second one is called preventive maintenance which is scheduled without the occurrence of any monitoring activities. The preventive maintenance may cause much more or much less maintenance activities, which may cause more maintenance cost or hazard of personnel and equipment. The last one is called Condition-Based Maintenance (CBM) which is also called Predictive Maintenance (PM) that is a set of activities that detect changes in the physical condition of equipment (signs of failure) in order to carry out the appropriate maintenance work for maximizing the service life of equipment without increasing the risk of failure. CBM is a dynamic schedule according to the state of equipment from continuous and/or periodic inspection. It utilizes the product degradation information extracted and identified from on-line sensing techniques to minimize the system downtime by balancing the risk of failure and achievable profits.

Mathematically, the maintenance scheduling problem is a multiple-constraint, non-linear and stochastic optimization problem. This kind of problem has been studied for several decades and many kinds of different methods have been applied to solve it. In the last two decades, many kinds of intelligence computational methods, such as the artificial neural network method, simulated annealing method, expert system, fuzzy systems and evolutionary optimization, have been applied to solve the maintenance scheduling problem and obtained many very exciting results (Yoshimoto et al. 1993; Satoh and Nara 1991; Miranda et al. 1998; Sutoh et al. 1994; Huang 1998). And also, with the rapid development of the evolutionary theory, genetic algorithms (GAs) had become a very powerful optimization tool and obtained wide application in this area (Back et al. 1997; Arroyo et al. 1997). In recently years, several new intelligent computational methods such as Ant Colony Optimization (ACO) and Particle Swarm Optimization (PSO) have been applied in preventive maintenance scheduling (Fatima et al. 2008; Pereira et al. 2006; Yare and Venayagamoorthy 2010).

All the above methods of maintenance scheduling are based on the specified time periods other than based on the condition of the equipment or facilities. However, there is no literature on applying the intelligent computational methods in CBM based on condition of monitored machines. Therefore, this article tries to build a CBM scheduling model and optimize it using BCA.

169.2 System Model for CBM

In order to show the general idea of applying BCA in condition-based PM scheduling, a manufacturing model is built assuming the features of the system that we analyze. There are several characteristics of the manufacturing system as following:

(1) The manufacturing system is subjected to deterioration.
(2) Periodically the system is under inspection and each inspection reveals the system deterioration state perfectly.
(3) Machine inspection is planned at the beginning of each period.
(4) The inspection time is very short and can be ignored compared to the whole period.
(5) Following an inspection based on the current state of machine (S_i), one of the following action is taken:

- $0 \leq S_i \leq S_k$: no maintenance is performed ($S_k$is PM threshold);
- $S_k \leq S_i \leq S_n$: PM is planed ($S_n$is CM threshold) but is not always performed;
- $S_i \geq S_n$: CM has to be performed.

(6) Following a PM or CM, the machine is restored to an as-good-as-new condition.
(7) The duration of PM action is much less than that of CM action for a same machine.

169.2.1 Modeling of Manufacturing System

The manufacturing system has a number of machines marked as M, and for each machine, the productivity is $Prod_i$. Therefore, the maximum productivity of this system can be expressed as Eq. (169.1) while its real total productivity can be expressed as Eq. (169.2).

$$Prod_{\max} = \sum_{i=1}^{M} Prod_i \tag{169.1}$$

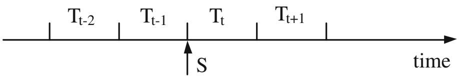
$$Prod_{tot} = \sum_{i=1}^{M} Prod_i \cdot \omega_i \tag{169.2}$$

where: $Prod_i$ is the productivity of ith machine. ω_i is the coefficient of ith machine productivity. The value of ω_i is 1 if the ith machine is not under any kind of maintenance, the value is 0 if it is under CM action, and the value is 0.5 if the machine is under a PM action in a period.

169.2.2 Modeling of Equipment Inspection

The value of the state can belong to arrange from 0 to 1 which represent the perfect state to the totally failure of the component. The state of machine is can be discretized as $S_1, S_2, \ldots, S_n$ which S_1 can be set equal 0 while S_n can be set equal 1

Fig. 169.1 Inspection point schematic diagram



or a value very closed to 1 (for example 0.98 which is the CM threshold). In this model, the beginning condition is considered for each interval. During each period, degradation of each machine is independent and random distribution according to Poisson distribution. At the start of each period, there is the inspection of a machine and the obtaining of the value of the state S of a machine. The states for all the machines can be used as parameters in predictive maintenance scheduling. (Fig. 169.1)

169.2.3 Deterioration Model for Each Machine

Deterioration means a process where the important parameters of a system gradually worse. If left unattended, the process will lead to deterioration failure. Therefore, the deterioration has to be considered when a maintenance policy needs to be employed. Figure 169.2 shows the deterioration model of a machine. The state S of a machine can be a value among $[S_1, S_n]$. In Fig. 169.2, $S_i(i = 1, 2, \ldots, n)$ is the predefined state of a machine, S_k is while S_n is CM threshold. P_{ij} is the transition probability for the state from S_i to S_j in one period. The PM should be planned when the state is between S_k and S_n. If the state goes to S_n, the CM action must be performed which means $P_{n1} = 1$. The state transition matrix P can be expressed as Eq. (169.3) with the constraint of Eq. (169.4).

$$P = \begin{bmatrix} P_{11} & P_{12} & \ldots & P_{1n} \\ P_{21} & P_{22} & \ldots & P_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ P_{n1} & P_{n2} & \ldots & P_{nn} \end{bmatrix} \quad (169.3)$$

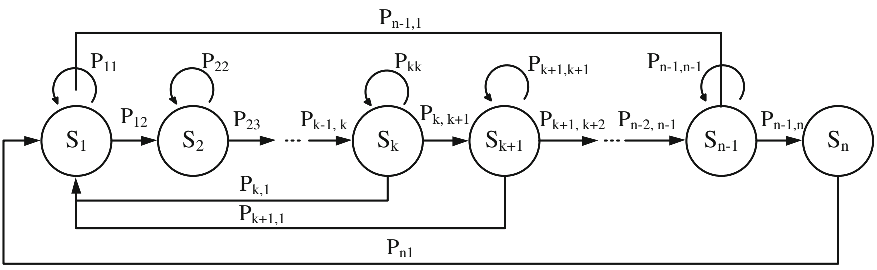


Fig. 169.2 Degradation model for one machine

$$\sum_{j=1}^{n} P_{ij} = 1 \quad \forall i = 1, \ldots, n \tag{169.4}$$

This model is very similar with the Markov model in lack of a random variable of inspection time. With the Markov, the mean time between *CM* and mean time between *PM* can be estimated (Amari and McLaughlin 2004). But with the Markov model, the accumulative error is very difficult to eliminate. The result is only the mean time between *CM* and mean time between *PM* rather than the real plan or scheduling of *CM* or *PM*. With that result, the maintenance action *CM* and *PM* could be much more or less than it necessary because of uncertainty of mechanical products. Therefore, the inspection action is performed in the beginning of every period as mentioned in Sect. 169.2.2. What's more, in this model, there is no any *CM* or *PM* action when the state of the machine is in the range between S_1 and S_{k-1}. The *PM* plan is made when the state of the machine is in range between S_k and S_{n-1}, and as mention above, the *CM* action is performed if and only if the state of machine reach or exceed S_n. To simplify the analysis, for the element values in the state transition matrix in Eq. (169.3), from the S_1 to S_{k-1}, only P_{ii} and $P_{i,i+1}(i = 1, 2, \ldots, k-1)$ have positive values and others are all zero, while from the S_k to S_{n-1}, only P_{ii}, $P_{i,i+1}$ and $P_{i1}(i = k, k+1, \ldots, n-1)$ have positive values and the others are all zero as well. The new equation can be expressed as Eq. (169.5).

$$P = \begin{bmatrix} P_{11} & P_{12} & 0 & 0 & 0 & 0 & 0 & \cdots & 0 & 0 \\ 0 & P_{22} & P_{23} & 0 & 0 & 0 & 0 & \cdots & 0 & 0 \\ 0 & 0 & P_{33} & P_{34} & 0 & 0 & 0 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \cdots & \vdots & \vdots \\ P_{k1} & 0 & 0 & 0 & 0 & P_{kk} & P_{k,k-1} & \cdots & 0 & 0 \\ P_{k+1,1} & 0 & 0 & 0 & 0 & 0 & P_{k+1,k+1} & \cdots & 0 & 0 \\ P_{k+2,1} & 0 & 0 & 0 & 0 & 0 & 0 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ P_{n-1,1} & 0 & 0 & 0 & 0 & 0 & 0 & \cdots & P_{n-1,n-1} & P_{n-1,n} \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots & 0 & 0 \end{bmatrix} \tag{169.5}$$

The ideal values of all the elements in Eq. (169.5) for the perfect deterioration model are express from Eqs. (169.6) and (169.7).

$$P_{ii} = 0 \quad \text{and} \quad P_{i,i+1} = 1, \quad i = 1 \ldots k \tag{169.6}$$

$$P_{ii} = 0 \quad \text{and} \quad (P_{i,i+1} = 1 \quad or \quad P_{i1} = 1), \quad i = k, k+1 \ldots n-1 \tag{169.7}$$

For the state of S_n in Eq. (169.5), $P_{n1} = 1$ and all values of other elements are 0 which mean that when the state reach S_n, *CM* has to be performed. These values could be a real situation of a manufacturing machine but it is difficult make the values reality. To achieve this point, the values of states from S_1 to S_n should be adjusted after a number of periods by statistics.

169.2.4 Modeling of Cost Function

There are many types of costs for each period which are analyzed one by one as in this section. All the costs calculated in this section are just for only one period.

Production Cost: it is due to the amount products produced by the manufacturing system which means how much money it need cost to produce the amount of products.

$$C_{prod} = Prod_{tot} \cdot C_{piece} \tag{169.8}$$

where C_{prod} represents the production cost for a period while C_{piece} represents the cost for producing one piece.

Maintenance Cost: it is due to the performing PM and CM, which means the how much money needed to perform the PM and CM.

$$C_M = \sum_{i=1}^{M} (CM_i \cdot C_{ci} + PM_i \cdot C_{pi}) \tag{169.9}$$

where CM_i represents if the ith machine is under the CM (0 means no CM action while 1 means under that action). PM_i represents if the ith machine is under the PM (0 means no PM action while 1 means under that action). C_{ci} and C_{pi} represent the costs of one CM and PM action respectively for ith machine.

Total Cost: it is the total cost for one period.

$$C_{tot} = C_{prod} + C_M + CI \tag{169.10}$$

where C_{tot} is the total cost in one period while CI is the inspection cost. Because in this model all machines are inspected for every period, the value of CI is fixed.

169.2.5 Modeling of Profit for the Manufacturing System

After above analysis, the total profit for one period can be calculated using Eq. (169.11). This equation could be an objective function for optimization. The total number of produced products in the period should be more than a minimum number which can be describe as Eq. (169.12). Furthermore, the number of CM and PM have a limitation because of the resources limitation, such as repairers and tools limitation.

$$\begin{aligned} Profit &= Prod_{tot} \cdot Pr - C_{tot} = Prod_{tot} \cdot Pr - (C_{prod} + C_M + CI) \\ &= Prod_{tot} \cdot Pr - \left[Prod_{tot} \cdot C_{piece} + \sum_{i=1}^{M} (CM_i \cdot C_{ci} + PM_i \cdot C_{pi}) + CI\right] \end{aligned} \tag{169.11}$$

$$Prod_{tot} \geq Prod_{\min} \tag{169.12}$$

$$\sum_{i=1}^{M} (CM_i + PM_i) \leq M_{\max} \tag{169.13}$$

where Pr is the price for one piece of product, $Prod_{\min}$ is the minimum amount products limitation of one period, and $M_{\max}$ is a limitation of the maximum maintenance action can be performed. In this model, to find the optimal dynamic predictive maintenance plan for each period, Eq. (169.11) could be an objective function and Eqs. (169.12, 169.13) could be two constraints. The aim is to make PM maintenance scheduling to obtain maximum *Profit*with two constraints of Eqs. (169.12, 169.13).

169.3 Proposed Method

Bee Colony Algorithm (BCA) is based on the waggle dance which was discovered by the Austrian ethnologist and Nobel laureate Karl von Frisch in 1967 (Frisch 1967). In the recent years some people has used this knowledge to develop algorithms to solve real problems. The BCA algorithm is inspired by the behaviour of honey bees during their forage (Fig. 169.3). In BCA algorithm (Karaboga and Akay 2009; Karaboga and Basturk 2007), the position of a food source represents a possible solution to the optimization problem and the nectar amount of a food source corresponds to the quality of the associated solution. The number of the employed bees and the onlooker bees is equal to the number of solutions in the population. The process of the behavior of bees to search food can be described as following (Fig. 169.3): the first phase is called employed bee phase. In this phase, every food source (FS) is visited by one employed bee (EB) who then take nectar to hive, and do the waggle dance in the dance area to express the quality of nectar. The second phase is onlooker bee (OB) phase. The onlooker bees will chose the food source to visit according to the waggle dance by the employed bees. The finally phase is scout bee (SB) phase. If the reaming food source is not good, the scout bees will be set out to find new food sources, take the nectar back to hive and dance in the dance area. The new food sources with the old ones will be combined together to be visited by onlooker bees and employed bees according to their qualities of nectar.

The algorithm of BCA can be described as following steps:

(1) Initialize the positions of solutions $\bar{x}_i$, the colony size (NP), the maximum cycle number ($maxCycle$), the number of parameters (D), and the number of trials to improve a source (limit).
(2) Evaluate the population.
(3) **Repeat** (Cycle = 1).
(4) Produce new solutions $\bar{v}_i$ (food source positions) in the neighbourhood of $\bar{x}_i$ for the employed bees using the following formula and evaluate those using (169.11).

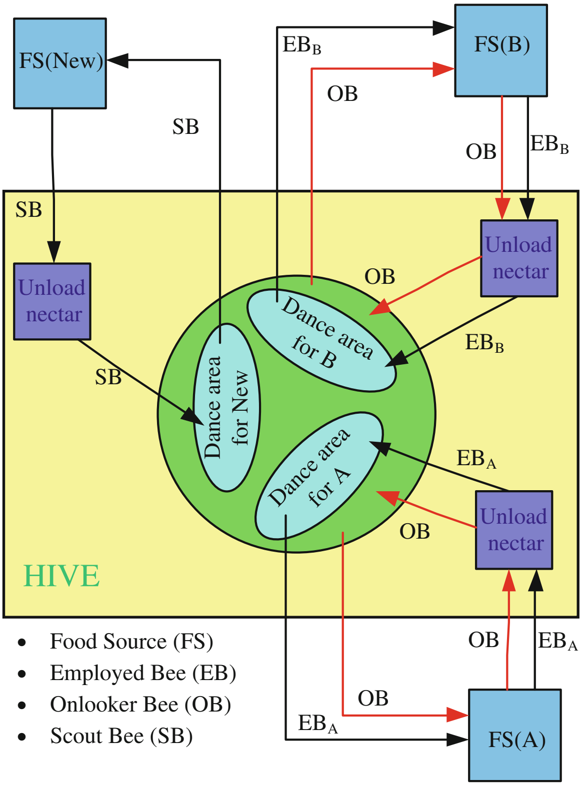


Fig. 169.3 The behavior of the bees

$$v_{ij} = x_{ij} + \phi_{ij}(x_{ij} - x_{kj}) \tag{169.14}$$

where ϕ_{ij}: Random number between [−1, 1], i: $\{1, 2, \ldots, C\}$ the ith food source, k: $\{1, 2, \ldots, NP\}$ randomly chosen index of neighbor which is different from i.

(5) Apply the greedy selection process for employed bees between $\bar{v}_i$ and $\bar{x}_i$.
(6) Calculate the probability value p_i for the solutions $\bar{x}_i$ by means of their fitness values using (169.15).

$$p_i = fit_i / \sum_{n=1}^{SN} fit_n \tag{169.15}$$

(7) Produce the new solutions $\bar{v}_i$ (new positions) for the onlookers from the solutions $\bar{x}_i$ using (169.14), which selected depending on p_i, and evaluate them.
(8) Apply the greedy selection process for the onlooker bees between $\bar{v}_i$ and $\bar{x}_i$.

(9) Determine the abandoned solution (source), if exists, replace it with a new randomly produced solution $\bar{x}_i$ for the scout using the following equation.

$$x_i^j = x_{i\min}^j + rand[0,1](x_{i\max}^j - x_{i\min}^j) \tag{169.16}$$

(10) Memorize the best food source position (solution) achieved so far.
(11) Cycle = cycle + 1.
(12) **Exit** if cycle = *maxCycle* or other criterion is met.

In the process of BCA algorithm, step (5) and (6) constitute the employed bee phase, step (7) to (9) constitute the onlooker bee phase while step (10) is scout bee phase. The problem of dynamic CBM scheduling is a kind of NP problem and the BCA is a good method to find the optimal solution for this kind problem. The numerical example is described in Sect. 169.4 to justify the effectiveness of application BCA in CBM scheduling problem.

169.4 Numerical Example

In order to investigate the performance of BCA for the condition-based PM scheduling problem, a test system comprising 30 machines is used. According to the conditions at the start of period, a dynamic PM scheduling is made period by period. The case study is described below and implemented in a MATLAB environment. In this case, the number of machine is 30, and the machine parameters are shown in Table 169.1. In the table, the $Prod_i$ means the one day productivity for ith machine. The problem of this case could be described as: making a PM and CM scheduling decision for 30 machines in a week according to the initial state of each machine.

There is no mathematical method to select the best population size of the BCA. However, there are some empirical parameters from experience. In this example, the value of population is set to 20. The profit (fitness value) for one period (a week) by the change of the number of iteration is shown in Fig. 169.4. The result of PM decision and CM decision are shown in Table 169.2. In the table, the values of PM are 0 or 1 which mean perform or not perform the PM action. The CM value is the same mean as PM. The optimal fitness value of this numerical example is 3081390. The result shows that BCA can make the dynamic PM scheduling optimization very effective and clear with PM model.

169.5 Conclusions and Future Works

Predictive maintenance scheduling has become a research interest topic in recent years. However, most of these kinds of researches are based on the fixed period.

Table 169.1 Machine parameters

Machine	$Prod_i$	C_{piece}	Pr	CI	S_i	C_{pi}	C_{ci}
M1	200	70	140	200	0.46	4000	10000
M2	200	70	140	200	0.51	4000	10000
M3	200	70	140	200	0.94	4000	10000
M4	200	70	140	200	0.55	4000	10000
M5	200	70	140	200	0.93	4000	10000
M6	200	70	140	100	0.96	6000	12000
M7	200	70	140	100	0.42	6000	12000
M8	200	70	140	100	0.66	6000	12000
M9	200	70	140	100	0.35	6000	12000
M10	200	70	140	100	0.35	6000	12000
M11	300	60	140	210	0.86	6500	16000
M12	300	60	140	210	0.95	5500	12000
M13	300	60	140	210	0.72	7800	16000
M14	300	60	140	210	0.82	8000	15000
M15	300	55	140	150	0.71	9000	17000
M16	300	55	140	150	0.64	6000	13000
M17	300	55	140	180	0.95	7000	15000
M18	300	55	140	180	0.75	8000	16000
M19	300	55	140	170	0.92	8000	16000
M20	300	55	140	170	0.66	8000	16000
M21	400	70	140	220	0.33	9000	20000
M22	400	70	140	220	0.5	10000	17000
M23	400	70	140	220	0.91	7500	20000
M24	400	70	140	220	0.6	10000	16000
M25	400	70	140	220	0.37	8400	20000
M26	400	70	140	220	0.97	10000	18000
M27	400	60	140	200	0.4	9000	18000
M28	400	60	140	200	0.46	9000	17000
M29	400	60	140	200	0.91	9000	18000
M30	400	60	140	200	0.7	9000	16000

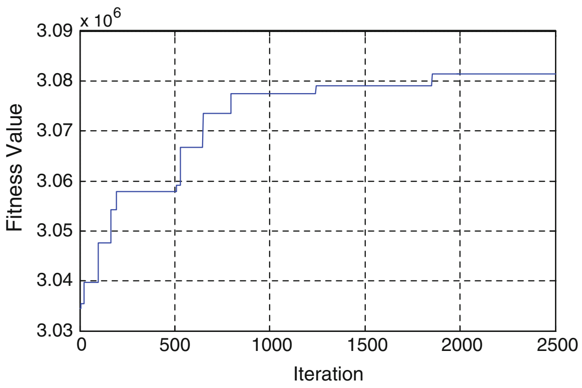


Fig. 169.4 Fitness value by the change of iterations

Table 169.2 Results of PM and CM by CBA

Machine	PM	CM	Machine	PM	CM	Machine	PM	CM
M1	0	0	M11	1	0	M21	0	0
M2	0	0	M12	0	1	M22	0	0
M3	1	0	M13	1	0	M23	1	0
M4	0	0	M14	1	0	M24	0	0
M5	1	0	M15	1	0	M25	0	0
M6	0	1	M16	0	0	M26	0	1
M7	0	0	M17	0	1	M27	0	0
M8	0	0	M18	1	0	M28	0	0
M9	0	0	M19	1	0	M29	1	0
M10	0	0	M20	0	0	M30	1	0

This paper introduced condition-based predictive maintenance that is making a predictive maintenance scheduling based on condition of machines. This article proposed a predictive maintenance model and applied PSO algorithm to make dynamic predictive maintenance scheduling optimization. It focused on one of the most common techniques of Swarm Intelligence: PSO, a population based stochastic optimization technique, inspired by social behavior of bird flocking, which tries to mimic the behavior of these kinds of flocks and how the particles of the flock communicate to achieve an objective like to search for food. The theoretical foundation of PSO is analyzed firstly and its application for solving a real problem (PM optimization) is described.

Although the desired results have fully achieved, and the analysis has helped to highlight and solve many critical issues, it is clear that more careful analysis should be done when analyzing PM maintenance model. In this paper, only one single kind condition for each machine. However, mostly, more than one parameters get together to determine the state of a machine. Therefore, how to get the state of a machine using different parameters could be a future research field.

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Chapter 170
Food CPS: A Healthy Diet Monitoring System Based on Internet of Things

Xiao-hui Xing, Yu Liu, Jian Zhang, Zhong Su and Ke-bei Zhang

Abstract This paper discussed the connotation and extension of two hot concepts, named "The Internet of Things (IoT)" and "food Cyber Physical System (CPS)". By analyzing their courses of development, history and interrelationship, and comparing their applications in daily life, the authors are in favor that food CPS can be regarded as an application of IoT in the human diet health. And build a healthy diet monitoring system based on Internet of Things. With this in mind, the authors discussed the key technologies of implementing food CPS and hoped to provide a reference on the development of people to enjoy a healthy diet and food networking.

Keywords Food CPS · Healthy diet · Internet of things · Monitoring system

170.1 Introduction

With the improvement of people's living quality, more and more people are trapped in "three highs" condition (high blood pressure, high blood sugar, high blood cholesterol) troubled. So people worry about health, many people use drugs

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to control the "three highs", but diseases usually come from the eating, we should do more monitoring and prevention when eating food. The earlier we start the low salt and low fat diet, low fat, the earlier we pay attention to the intake of nutrients, it will be better to our health.

However, the difficulty lies in the monitor and measurement of daily food intake and long-term recording and analysis in the control of people's dietary intake. The best way to monitor and measure dietary intake is the Internet of Things technology, it can collect dietary intake data through a variety of sensors and other automated equipment, and then automatically aggregating, recording and analyzing (Zhang 2010).

Today, the Internet of Things technology is developing rapidly. Personal real-time health monitoring and service platform based on the Internet of Things has been proposed. The platform can help people understand their health status in real time, and can further indicate how to improve their health (Burns 1998; Duquennoy et al. 2009). However, the platform only provides real-time monitoring of personal health status, and it cannot solve the fundamental problems. Although the platform can propose the program to improve diet based on the current state of personal health, it cannot control and measure the specific in taking amount.

Taking into account that the key to maintain health is how to control the amount of healthy food and how to have a reasonable food intake, the paper proposes a dietary health monitoring system based on the Internet of Things, The system can not only monitor people's health in real time, but also can put forward diet program based on individual health status, The most crucial innovation of this system is that it can measure individual's food intake timely, then aggregate and feedback to the user timely.

170.2 Internet of Things and Food CPS

170.2.1 Internet of Things

Internet of Things suggests that all things linked to the network are defined as a kind of network, which any items can be connected to the Internet together and exchanging of information and communication in order to achieve intelligent identify, locate, track, monitor and management (ITU Internet Reports 2005). The sensing devices used in it are radio frequency identification (RFID), Global Positioning System (GPS) and others. Since introduced, the Internet of Things has developed rapidly, called the 3rd wave of the world information industry following the computer and the internet (The Internet of Things 2005). The Premier Jia-bao Wen pointed out that promoting the "triple network" into integration and acceleration the development and application of the Internet of Things should be quicken in the government report in March 5, 2011 (EpoSS 2008).

170.2.2 Food CPS

The food network is a kind of network, which is information network platform that gather information of all ingredients of the food we consume. The electronic devices embedded in dinnerware (such as chopsticks, spoons, bowls, etc.) can set information out by wireless technology. The information of food ingredients can be extracted static or dynamic. Then, Used these information, the food network generate personalized dietary guidance reports. The Fig. 170.1 shows that food network will be connected to food and eating tools and infrastructure in community in order to achieve information exchange in real-time and offer serve for a healthy diet of people.

In the network, the main equipment is divided into two categories. The one is the sensors for the detection of food ingredients. The others are the data processing equipment. The sensors for detect the food ingredients are as follows: (1). the sensors of Spreeta series are used for detecting proteins. The device can be done as the size as a coin. (2). the technology used in the tablespoon (Patent No. ZL 200, 820, 019, 924.6) is adopted to detect salt in food.

The devices in data collection and processing are mainly to the microprocessor of C8051F38x and C8051T62x/32x in series. Meanwhile, the F05P Series modules can be used in the wireless transmitter module. The advantage of F05P is that the emission current (10 mA) is small as well as shape structure (9 × 21 × 5 mm) (Rellermeyer et al. 2008).

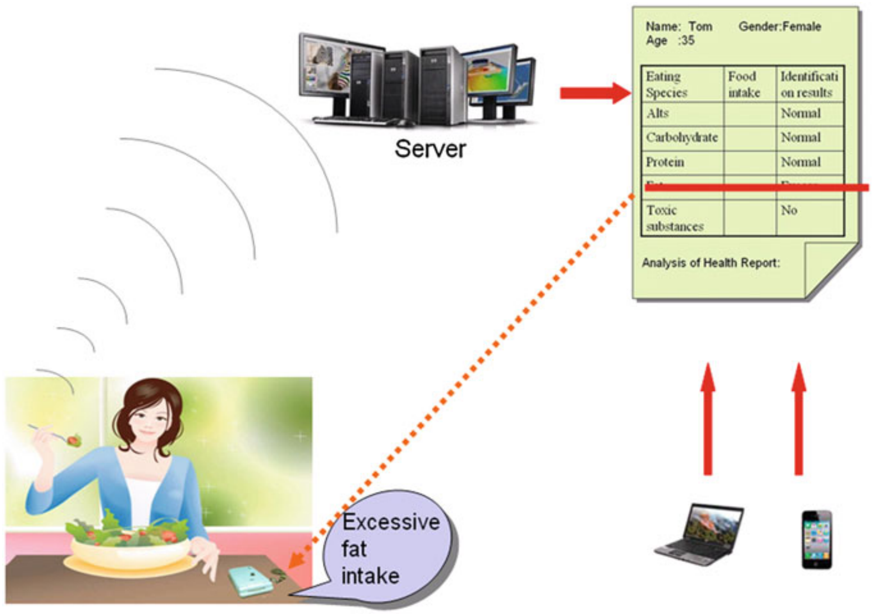

Fig. 170.1 Food CPS schematic diagram

170.2.3 Internet of Things and Food CPS

The Food network is a class network of things. It is application of network of things in people healthy diet. In the network, the dinnerware can collect data dynamically and transmit information to base stations in a method of wireless communication. Therefore, the exchange of information between the base station and the people, the connection between dietary intake and intelligent network are become impossible.

The technology used in Food networking is a combination of biological sensors and wireless communication technologies so that a diet health monitoring system is established (Shi 2009). Using wireless network, person can contact the base station at any time and has access to the following two categories server: the one service is personal diet diagnostic; the other is dietary information and real-time guidance. With help food networking, personal diet will be more healthy and humane.

170.3 Research Review

170.3.1 Domestic Research Review

Induction spoon (Patent number: 200820019924.6), this patent can response salt concentration by the spoon sensor. This patent can be used for measuring the salt concentration, but it only can be used for measuring the single ingredients. And the measurement data cannot be processed and transferred (Lee et al. 2010).

Personal real-time health monitoring and service platform based on Internet of Things, it has been proposed in the "Chunhui Cup" Innovation and Entrepreneurship Competition of Chinese students by the team (Li 2009). And it has been included in the ten demonstration projects of Jiangsu Things of Industry. It has completed the transformation from concept to practical application of systems, and it has formatted a complete system initially (LIn et al. 2008). This project is just a real-time monitoring system for personal health situation. Analyzing only from the perspective of health monitoring, it its palliatives. This project is not take it into account of that the source of healthy is how to keep a healthy diet and how to intake food reasonably.

170.3.2 Foreign Research Review

The IC3 Cutlery has been presented and displayed at the Designparcours 2008 exhibition in Munich, Germany. It's made-up of a computerized handle and three interchangeable eating tools: a fork, a knife and a spoon, each with their own special features. The fork measures food composition, such as fat, sugar or protein levels, the spoon weighs your bites and the knife acts as a thermometer, taking temperature readings from your food. But it cannot be achieved interconnection with the network (Armenio et al. 2009; Atzori et al. 2010; Pu 2006).

In summary, researchers and companies at home and abroad have realized the Internet of Things applications into a healthy diet. However, due to the Internet of Things as an emerging technology, it is still in the stage of development, and the concept of Food CPS has not been formally proposed (Krejcar 2009; Pavlovski et al. 2004). Therefore, the innovation of this paper is that it applied IoT to the monitoring and prevention of a healthy diet and put forward a new concept of the "Food CPS". The author also hopes to provide some help for the comprehensive development of the Internet of Things.

170.4 A Healthy Diet Monitoring System Based on Internet of Things

170.4.1 System Design

The Diet-Health-Monitoring System, based on IoT, has three components which are intelligent cutlery, community service station and information receiving terminal.

Intelligent cutleries collect data and deliver to the community service station, which will quick determine whether the diet condition is qualified, whether the amount of fat, salt and any other elements are over the standard. At the meantime, the service station will remind people to adjust diet style. On the other hand, the service station automatically generates diet health report which is available on community website. People can login this website and look up personal diet and health profile. In this way, people will have a better understanding of the self-diet health condition.

As to the data transmitted from the detector, it will be transferred through the wireless transmitter module to service station which will process the data based on pre-designed rules, and then give feedback to users. The topology of IoT is showed below, as Fig. 170.2.

The embedded sensor module and WiFi module in the intelligent cutlery are used for collecting information about the amount of food taken in and transmitting the information to service station. After getting the information, the work station will summary and store data and then analysis data in order to provide a result for users. Compare to wired transmission network, the wireless transmission network has a simple structure that is easier to operate. It also greatly reduces the workload of field wiring and decrease the cost. The structure like this is flexible and scalable.

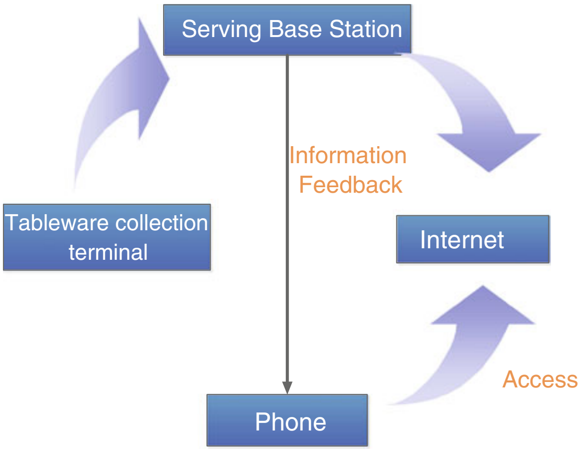

Fig. 170.2 The topology of the monitoring system of a healthy diet

170.4.2 Data Collection and Delivery

Intelligent cutlery includes intelligent chopsticks, intelligent bowls, and intelligent spoons and so on. Intelligent chopsticks can used to detect the existents of Pb and Hg and other toxic substances. Intelligent spoons can used to measure fat, salt, sugar, protein content. This article will only use intelligent spoons as an example to explain the data collection and delivery. The structure of intelligent spoons is showed in Fig. 170.3.

At the front-end of the spoon is equipped with biochemical sensors, followed by data collection module, data processing module, wireless launch module, indicator and switch.

The biochemical sensors are the equipment which can sense biological and chemical content, then convert to available signals (electrical signals, optical signals, etc.). It is usually divided into two parts: one is biochemical molecular recognition elements (receptors), which is built up by sensitive materials which biochemical molecular recognition ability (such as the chemically sensitive film of

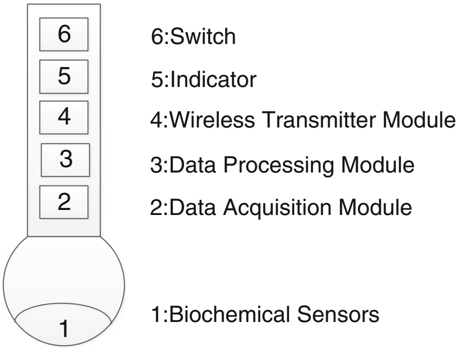

Fig. 170.3 Structure diagram of intelligent spoon

electro active material, semiconductor materials and formation by enzymes, microbial DNA, biologically sensitive film). And another part is signal convertor (transducer), which mainly assembled by the electrochemical or optical detection devices (such as current, potential measuring electrode, ion sensitive field effect transistor, piezoelectric crystal, etc.) The biochemical sensors at front-end of the spoon transmitted the information about the perception of biomolecules to data collection module; And data collection module convert the data to recognizable data, then transfer to the wireless launch module; finally, the wireless launch module transfer diet information to service station through WiFi.

170.4.3 Data Processing and Searching

Service stations process the information collection and provide result to users for the purpose of guiding people to adopt a proper diet style.

Service station stores the reports of every individual user, the processor will design personalized reasonable diet range according to each report. While users take in less or more than the certain amount of components, the processor will remind users automatically. After every meal, the work station will add up the data and suggest a proper diet range for the next meal.

At the same time, in order to help users to be aware of their diet health condition, it is allowed to login database through computer and mobile phone to look up the health status and proper diet elements.

170.5 The Feasibility and Risk of the Key Technology

170.5.1 Analysis of Technical Feasibility

The Food Network is a class network of things. Many of the key technologies are used in Internet of Things can be implemented in the food network. But technologies support for applications of Food network are also different from other things.

With the mature development of, the microbial sensors generation and application, real-time processing system and so the rapid development of information technology, the technologies used in Food network are strengthen. Among them, the key technologies in food networking include:

(1) Technology for detect food composition;
(2) Technology for fingerprint recognition;
(3) Technology for communications and network;
(4) Technology for hardware and software;

The primary condition for achieving food network is the succession of detect ingredients in the food inspection. The ingredients detected are including sugars, proteins, fats, hazardous substances such as mercury, sodium nitrite. The sensors to detect these substances should be integrated into the surface of the dinnerware. Therefore, the sensor must be small enough such as biosensor. Fortunately, the technologies in micro-mechanical sensors, thin film sensors and Nano-bio-sensor has become more sophisticated so that the accuracy of detect food ingredients is increasing. All of these provide reliable technical support for food network. Its main sensors are including the sensors for detecting glucose, the sensors for detecting fat, and the sensors for detecting protein (e.g. series of Spreeta biosensor). Although technology of some sensors is not very mature or not born, it is believed that the sensors for detecting various ingredients will come into being in the near future as the microbial sensor technology continues to evolve.

Communications and network technology are the main technologies to achieve the link between the information tableware collected and community service centers. Community service centers will establish network called WiFi to provide service. When have accessed to the WiFi, the wireless module Integrated in the tableware set the data the tableware collected to the community service centers automatically.

The hardware includes all bio-sensors devices, microprocessors, and wireless module. Because of characteristics of the Internet of Things as well as tableware, the integrated terminal detection systems should be embedded in the dinnerware. The terminal detection system is miniaturization, low power consumption, easy placement, and low-cost. The microprocessor references C8051F38x and C8051T62x/32x the USB MCU. In the aspect of software and algorithms, it comes to deal with data tableware collected, information processed and a dietary intake data sheet for all ages. Basis on the software and algorithms, the data reports of diet and dietary advice will be generated. Meanwhile, the web page is created for customer inquiry.

170.5.2 Analysis on Risk

Whether the food network is success or not depends on the biosensors integrated in the dinnerware. The diversity of biological sensors to detect ingredients and the durability of the biosensors are two main risks to determine whether the food network achieved (Schwarz and Silva 2007).

The one is whether the variety biosensors can be integrated to limited space in tableware; the other is risk the tableware cleaning posed to the bio-sensors, microprocessor and wireless module.

Due to the limited space, the shape and size of the bio-sensors are challenged significantly. One idea to resolve the problem is that different sensors are integrated in different dinnerware. The other one thin-film sensors are adopted to integrate into the tableware, as illustrated in Fig. 170.4.

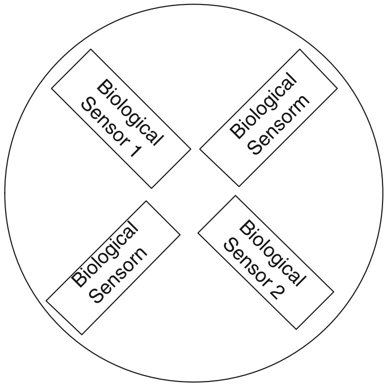

Fig. 170.4 The Schematic diagram biological sensor integration

Uncertain risks brought by the cleaning of tableware to terminal collection system are the main factors we should considered. Influence caused by tableware cleaning and cleaning fluid is harmful to the biological sensors, microprocessors, such as performance, life incalculable. It is necessary to consider the performance, as well as anti-jamming impact of biological sensors and microprocessor when choose equipment.

170.6 Conclusion

Nowadays, more and more people concern about the health. Diet is a vital part to define whether people are healthy. This article studied about a diet-health-monitoring system based on IoT from the point of view of diet elements, nutrition components and toxic existence. We hoped that people adopt a healthy diet style to make the life better. This system is applicable for a wide usage. Other than the "Three High" people, the people who are willing to lose weight in a healthy way can try to use it. The detection can be better in the future, the possible direction to improve it is making it to be suitable for the people have different physiques and different requirements, and to be a "personal nutritionist" to suggest people with different food menu. We believe that the system can be a genuine humane system.

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Chapter 171
Multi-Functional Music Auxiliary System Based on Voice Recognition on Tablet PC

Mu-yan Li, Fang Han and Gan Zhang

Abstract A music auxiliary system based on tablet PC is presented in this paper, which is called Music Revolution. Because this music auxiliary system is able to free instrument players' hands through tablet PC, help players turn over notation pages through voice recognition technique, and also automatically play the beat, it brings player a better experience in the process of performance. Meanwhile, it also helps players analyze their emotional coloring and tendency during the play, to reach a self-examination and self-improvement, in order to have better interaction experience and practice efficiency. And it is also a new concept, which perfectly combines art with science and technology means.

Keywords Music auxiliary · Tablet PC · Voice recognition

171.1 Introduction

Music has become a necessity for most of people's daily life in modern time. It gradually becomes a kind of spirit food for common people, instead of just a recreational form of the aristocracy (Liem 2011). Therefore, people are more and more close to music, come up to music and everyone enjoys music in their daily life incessantly. At this case, music learning has become a necessary part in many people's daily life, particularly in children's life (Gorder 1980).

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But it is inconvenient situations to turn over the notation pages when people are in a practice process of musical instruments, especially some instruments that need bimanual performance (like piano, violin, accordion, etc.). If musical notation turning is required, it is necessary to interrupt playing and do page turning. It decreased the fluency of playing, together with the aesthetic quality and efficiency of practice (Reber 2004). And if there are not the help from the music teacher, a person does not know the results after he finishes his performance and does not know where his performance poor in.

According to those problems, a music auxiliary music platform that improves the instrument players' experience, which is called Music Revolution was proposed in this paper and designed and finished by the authors. It integrates functions like speech page turning, comparison and evaluation of performance situation, electronic metronome, performance back listening, etc. This music auxiliary system is based voice recognition technique on tablet PC. And this music auxiliary system is very useful and convenience for the modern music player to do practice.

171.2 System Description

Music Revolution Music Platform aims at improving current as well as inherent performance environment for users and bringing them with better music quality and performance enjoyment.

In view of users, musical performance is a fluent and coherent process (Liem 2011), but the intermittent caused by page turning breaks the fluency. Even if the basic coherence of chapter can be guaranteed, yet much attention need to be paid for page turning and emotion will be interrupted due to the moment of page turning. Therefore, senior players will be assigned with professional assistant sometimes, but this cannot be realized while in the process of individual exercise (Fig. 171.1).

In view of music quality, sound-processing mechanism of the platform quantizes the real-time audio signals it receives and doing quantitative analysis. Because one of the most common and important performance actions is changing the loudness of the piece as it is played (Kirke 2009). It's the reflection of the music's emotion. So it's necessary for the player to check whether their playing is consistent with the composer's original idea, though the tendency of loudness data during their play. In Music Revolution, firstly, parts of environmental noises are filtered according to frequency of the chosen instrument, then a "time–loudness" graph is drawn. The significance of graph is to help players to know the emotional coloring of each part while in the process of performance. As faults like note errors are easy to remember in practice process, the priority of detailed parts, however, is difficult to note. The crescendo and diminuendo as well as ups and downs of emotion are the core parts to determine the performance level, which, however, can do individual analysis and presentation through comparison of the graph and have improvements eventually.

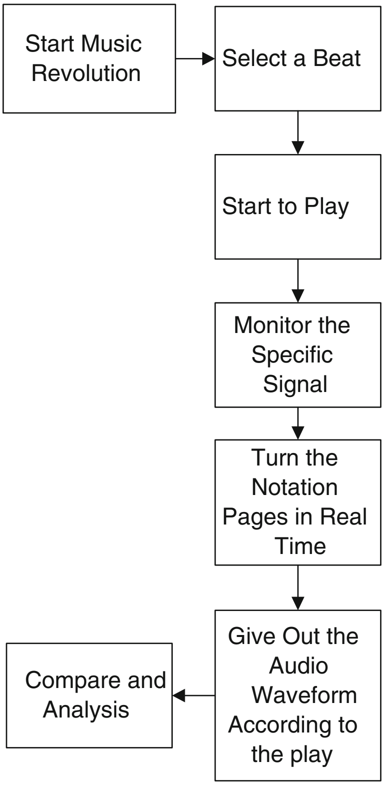

Fig. 171.1 Flow chart of music revolution system

Therefore, speech page turning of Music Revolution starts from the view of people first and provides players with a better individual performance environment. Moreover, the analysis and inter comparison function on music performance with records afterwards is a ladder to help people with level improvement. And it supports the manual adjustments to graph and the listening test afterwards, thus to improve individual performance gradually. Besides, it also has advantages like portable and rapid, etc. and the auxiliary functions like electronic metronome, which contributes players to have a chapter library and set the natural rhythm of different chapters, making practice and performance efficient and convenient.

171.3 Function Design

171.3.1 Page Turning Based on Voice Recognition

Talking to the machine, make the machine understand what you say; it is a long-standing dream of people (Chen et al. 2011). The voice recognition is a senior technology, which makes the machine recognize and understand by turning the sound signal to appropriate text or command. Now there're lots of innovative interactive systems using voice recognition as the base of interaction (Shi 2003). Voice recognition technology includes feature extraction technology, pattern matching criterion, and technology of model training. There we use the first one in Music Revolution.

Firstly it requires the user to repeatedly record a fixed page turning word as a voice command (Kim 2012). After each recording, the program will keep the recording, and organize its code. When it obtains several voice commands corresponding to the code, system will analyze and record the common part of the code, and conduct feature extraction. In this way, we obtain a standard "page turning command library". When the users use page turning command in the process of playing, the standard command library will compare the command to a number of stored commands, as long as they meet pre-set criteria, they will be identified as the page turning command, and automatically implement page turning.

171.3.2 Audio Waveform

Each instrument is corresponding to a different voice frequency band. For example, piano's corresponding frequency bands are 27.5 Hz–4.86 kHz, flute 250 Hz–1 kHz, this determines the timbre fullness, and during 5–6 kHz it influences the timbre brightness. Trombone's corresponding frequency bands are 100–240 Hz, and in 500 Hz–2 kHz will have splendid timbre. Therefore, the first step is to select the corresponding instrument ahead of the play. After the selection, the system will choose the instrument's inherent frequency bands.

During the playing process, those overstepped frequency bands will be considered as a noise part, which will be ignored when drawing loudness images. Wave filtering process will adopt Fourier transformation (Yi 2011). This method will cause a small delay in terms of speed, yet due to its cost savings advantage, and the formation of the image does not require a very high speed. In the meantime, from the amplitude spectrum of wave filter and the Fourier transform, we can find a difference. The amplitude spectrum of Fourier transformation, it is instantaneous become 0 from certain numerical value. However, it is very slow after processed by the wave filter. As long as both of them selecting appropriate numerical value in the filtered part, it can still achieve the same effect, so we think that this transformation is feasible and effective. As the system gets the music response, it draws time-loudness curve by using X-axis as time and Y-axis as loudness. The curve shows the player's emotional changes in a recent performance; in the meantime it also shows the problems that players need to improve (Lehmann 2007) (Fig. 171.2).

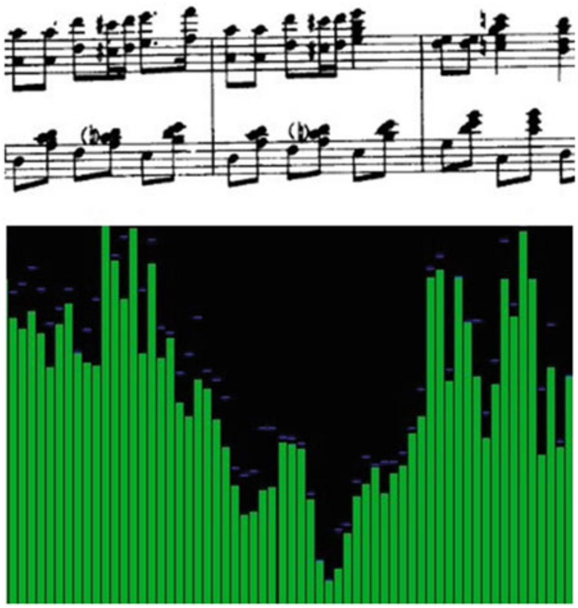

Fig. 171.2 The audio waveform generated

171.3.3 Digital Metronome

The metronome module is to transplant the tangible metronome into the tablet PC, at the same time making some improvement. Comparing to the tangible one, the metronome on tablet PC is much more convenient, and free from daily cleaning. Meanwhile, the instrument player can name the tempo, or bound different music piece to different tempo, in order to reuse it easily in the future. And the loudness of the metronome can be adjusted, to adapt different environments (Fig. 171.3).

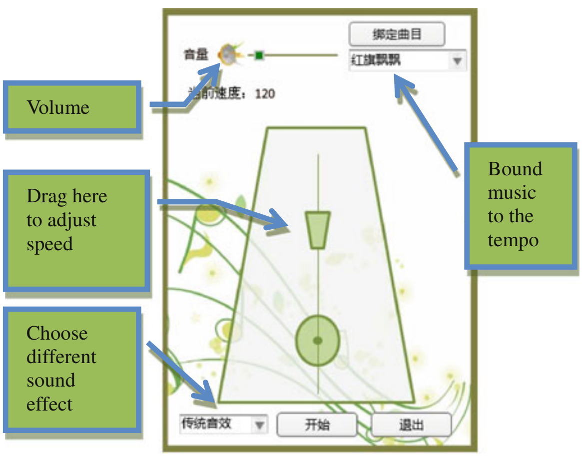

Fig. 171.3 Interface of the digital metronome

Fig. 171.4 A piano player is comparing music revolution to the traditional notation

171.4 User Feedback

Our test is carried of 20 instrument players, which are relatively skilled, playing instruments for at least 18 months or above. And all these 20 subjects have passed the informal Chinese Mandarin test in order to assure they're able to control the system by voice successfully. To prevent the negative influence caused by the nervousness and strangeness in a new playing environment, the subjects were permitted to choose their own test environment freely, in which they are most familiar with, for example, their own music room (Guha 2010) (Fig. 171.4).

Some standards of choosing test music pieces were set. Firstly, the subject should have practiced this piece before, to some degree, in order to prevent stupid mistakes such as fingering faults. Secondly, the subject shouldn't have memorized the piece, needing the help of notation to continue playing. Thirdly, the music piece should be more than 2 pages. All the music pieces for test have been made into digital notations, with the same layout of paper notations, which the subjects were familiar with, and stored into the tablet PC.

Each piece of music was played twice, with 10 min in the middle, to provide necessary rest, and to erase subjects' short memory of the notation (Sylla 2012). Subjects use paper notations and SONY ICD-FX8 recorder pen in the first time. After 10 min in the second time, use digital notations and recorder on the tablet PC. Meanwhile, draw the time-loudness curve. After all the playing, analyze the curve immediately.

One goal of the test is to investigate the experience of page turning. Among the 20 subjects, 14 believed that turning paper notation papers would have negative influence on applying play skills and expressing emotions, and the other 6 subjects believed there's little influence. Then the subjects analyzed the audio curve of the first play (with paper notation) with stuffs, especially when the player was turning pages. After that, there're 16 subjects instead of 14, believed that negative

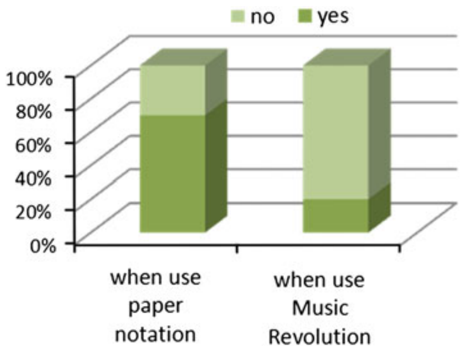

Fig. 171.5 Does turning pages interrupt your play process?

influence indeed happened. After trying verbally controlled page turning, 16 subjects indicated that it's a pretty comfortable and fluent experience, having no effect on the play itself. However, 4 subjects felt worried about the voice control method. After analyzing the audio curve of the second play, only 5 subjects indicated that turning pages verbally still influenced negatively. And the other 15 thought that turning pages verbally have solved the former problem perfectly (Figs. 171.5, 171.6).

The other goal of the test is to check the audio curve. 10 of the subjects believed that the curve is useful, could indeed help improve the play quality. Other 6 subjects indicated that this function remains to be improved. They confirmed the curve's ability to indicate the play's emotion change and loudness change, but pointed out that it's sometimes confusing because of the imprecisely correspondence of notation piece and its curve. And the other 4 subjects thought there's no difference between analyzing the curve and traditional way of listening to the record.

Additionally, when talking about the metronome, the entire 20 subjects liked it, indicating it's indeed more convenient than the tangible one.

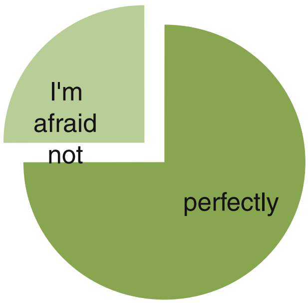

Fig. 171.6 After analyzing the audio curve, do you think Music Revolution has solved the page turning problem?

171.5 Future Work

There're two main problems found in the user feedback. Firstly, sometimes the voice recognition is useless because of the different accents of users. Secondly, the audio curve is not precise enough to find out some gentle emotional changes. In the next period, we're going to solve these two problems.

171.6 Conclusion

Music Revolution—the multi-functional music auxiliary system prestores digital notation on tablet PC contributing players to experience much better when playing an instrument. Instead of traditional paper notations and tangible metronome, players have all these functions, which have been improved to be more humanized, on tablet PC. By providing the digital notation, which can be turned verbally, Music Revolution solves the problems that the players have to stop their performances in order to turn the notation pages manually. The audio curve drawing module will filter the environment noises according to different instruments and draw a "time–loudness" curve, contributing players to analyze their emotional tendency during the play, and improve themselves purposefully. Meanwhile, the electronic metronome integrated with many functions makes the players' performances more standard, and have lots of advantages comparing to a tangible one.

After some users' experience, they indicated that Music Revolution is really creative and helps a lot during the instrument play. It did promote the players' experience, help them examine themselves and improve performing level. In this way, the player will get a better experience on playing instruments together with a high efficiency on practicing.

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Chapter 172
Research on Path Planning of Intelligent Transport System Based on Improved Bidirectional Search

Rui Wang and Zai-tang Wang

Abstract In this paper, path planning algorithm based on improved bidirectional search is set forward in this paper. A typical algorithm for the shortest path computation is considered Dijkstra algorithm, Its time complexity is $O(n^2)$. But a city' s road net map has many nodes, time complexity of the algorithm is too high and solving is too slow. To improve the situation, the data structure of the city's road net and design of the algorithm are discussed, and then improved bidirectional algorithm is proposed. Practical implementations prove that the improved bidirectional algorithms can reduce the storage space and increase the search speed.

Keywords Bidirectional search · Intelligent transport system · Path planning · Shortest path

172.1 Introduction

Intelligent Transport System also called Road Transport Telematics (RTT) in Europe is a new transport system based on high tech including system engineering, electronics, telecommunication and informatics, and which penetrated into airborne, railage and marine(Yang et al. 2000). The dynamic vehicle path planning problem is one of the cores in Intelligent Transport System (Koutsias et al. 2000). How to improve the speed of the path planning algorithm is the premise that the intelligent

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transportation system better and faster development. According to the different requirements of the drivers on the path, we can take different planning standards in the path planning (Ahuja et al. 1990). Such as now commonly used: the shortest path, the shortest travel time, the lowest cost and so on. No matter what kind of drivers using requirements, we seek the lowest cost in the city's road net, is what we used to say "the shortest path" problem (Zhan 1997). The current representative of the shortest path algorithm is Dijkstra, its time complexity is $O(n^2)$, that n is the number of nodes (Ran and Lee 1998). But Dijstra algorithm is a NP algorithm, which is the uncertain polynomial complexity algorithm (Eppstein 1999). Facing the city's road net map many nodes, the algorithm of time complexity is high, solving speed is slow, it is difficult to meet the navigation system in real-time and Dijstra used a two-dimensional matrix to describe the graph vertex and arc, while the city' s road net in each vertex usually only 3–5 adjacent arc, not with all the vertex have connection arc, therefore the use of two-dimensional array of storage not only waste storage space will also increase the computer's judgment times of not connected vertex. Now also have a lot of the shortest path algorithm, but many of the nodes in the network, most of the algorithm is hard to meet the quickness of path planning, this article from the data structure and algorithm design of the existing bidirectional search algorithm optimization, the experiment proved, can improve the efficiency of the algorithm, make its applicable to the intelligent transportation vehicle navigation system.

172.2 Algorithm Optimization Principle

The Bidirectional search refers to the search along the two directions simultaneously. Forward search: From the source node to the destination node direction search; Reverse search: From the destination node to the source node direction search. Each new node is created, not only with the queue of each node to determine whether the repetition, and also determine whether the repeat with the other queue. If have the same node, two directions search meet, search finish, bidirectional search steps is equal to the sum of two directions that include forward search and reverse search. The spanning search tree is diamond, greatly reducing the number of search nodes, improves the efficiency of search. Bidirectional search has two way of search: one, a forward-reverse two directions search at the same time and the other, expand the direction of the node numbers less. The second way overcomes the first way shortcomings which two directions of the nodes generating speed unbalance state, improving the efficiency obviously. Experiments show that it compare with unidirectional searching algorithm, bidirectional search expands node numbers can at least reduce 1/2 (Lu 1989). Search efficiency is improved obviously.

This algorithm is optimal state that forward and reverse search meet in the graph, and the algorithm efficiency is the highest. The worst state is the two directions search have no intersection, which forward and reverse two directions search cannot meet in the graph, it make the bidirectional search algorithm time doubled. So the appropriate relax termination conditions can shorten search time. Improved algorithm solves nodes do not meet conditions in bidirectional search without increasing the time complexity of the algorithm.

In the search process, each new node do projection to the line of the source node and the destination node, calculation the distance that the new node from the forward search to the source node and the new node from the reverse search to the destination node, and calculation the sum of two distances, if the distance is longer than the distance between the source node and the destination node connection's distance, we think the bidirectional search won't meet, stop a certain direction search and another direction search is continued. Which direction search to stop or continue in bidirectional search mainly depend on which direction the node numbers less; we expand the direction of fewer nodes. This ensures that time complexity of the algorithm; this algorithm is applicable to intelligent transport path planning's characteristic. In this project, we use the improved bidirectional search algorithm to search the city road network's shortest path. It is well known that "a straight line is the shortest distance between two points", if we want to search nodes exactly at the same edge, this edge is that we want to find the shortest path, otherwise, the edge that minimum angle of the line is probable the shortest path (Yan and Liu 2000). As shown in Fig. 172.1, the improved algorithm steps of the shortest path between A and E in the city road network are as follows:

(1) Node A for source node and node E for destination node. Between node A and node E, connect a line AE, if the graph has an edge coincide with AE, this edge is the shortest path we search.

(2) If do not meet the above conditions, we search the edge that minimum angle with the line AE from the source node A and the destination node E to central at the same time. In the search process, we always expand the direction of fewer nodes.

(3) Repeat steps (2), until two directions of search can converge on the same node or the same edge. The shortest path from A to E is the nodes set that search from the two directions.

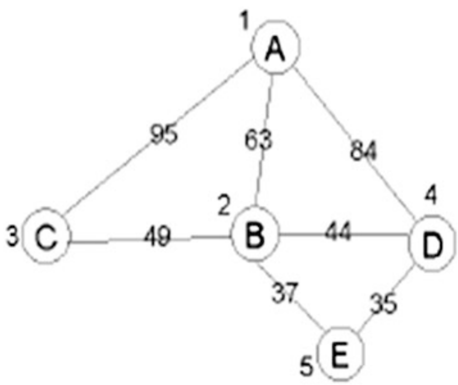

Fig. 172.1 Graph of network simulation

(4) In the search process, the new nodes from two directions search do projection to the line AE, calculate the distance between the new node's projection that comes from A node's direction search and A node and the distance between the new node's projection that comes from B node's direction search and B node, and calculation the sum of two distances. If the distance is longer than the distance between the line AE's distance, we think the bidirectional search won't meet in the graph, stop search a certain direction and another direction search that has fewer nodes continue expanded. At last, the shortest path is the unidirectional expanding node's set.

172.3 Path Planning Algorithm Design

172.3.1 The Storage Structure of the City's Road Net

The topological structure is the foundation of the path planning; a good data topological structure can reduce the memory space, and play an important role of the efficiency of the algorithm. Topological data in Intelligent Transport System mainly refers to the sum of the network's nodes and arcs (Zhong 2004). In order to obtain the applicable city traffic network graph, the road must be split into the basic road sections, so it only connects with other road sections at endpoint. After a reasonable split, the city road network can be abstracted by nodes and edges into a topological relation. In the topology relationship, node used to represent the intersections of the road or path endpoint. Each node has a number; node can use the corresponding number to express. Edge used to represent two nodes is connected, and weight edges express two cross point distance. But in the actual city's road network often meet radian larger road, we adopt corresponding increase some nodes in the road section, connecting these new nodes, make it similar to become an edge. Through the above process, we make whole city's road network is simplified into a graph that only with the weight edges and nodes.

Storage structure of graph directly influences the search speed of the algorithm. According to the characteristics of city's road network and algorithm, we use the adjacency list to store graph. In the adjacency list, each node has a number and creates a single linked list; each single linked list consists of head node and list node. Head node storages geographic information of intersection, for example: the longitude and latitude of the node and node number and so on. The list node after the head node storages the information of intersection of the associated nodes and edges that with the current head node. It's easy to find the node and other connected nodes information. In this structure the head node take sequential mapping storage mode, the structure is beneficial to the random access network of arbitrary nodes. It is easy to search algorithm implemented. The following is the definition of graph structure.

```
struct node{       //head node
int  NodeName;    //node numbers
float x,y;          // longitude and latitude coordinates of
nodes
struct vnode *link;  // point to the next adjacent node
}
struct vnode{      // list node
int  NodeName;   //node numbers
float weight ;      // The edge weight
struct vnode *next;  // point to the next adjacent node
}
```

172.3.2 Algorithm Implementation

Bidirectional search efficiency depends on whether the two directions search can meet in the same node or the same edge. The new nodes from two directions search do projection to the line AE, calculate the distance between the new node's projection that comes from A node's direction search and A node and the distance between the new node's projection that comes from B node's direction search and B node, and calculation the sum of two distances. If the distance is longer than the distance between the line AE's distance, we think the bidirectional search won't meet in the graph, stop search a certain direction and another direction search that has fewer nodes is continued expanded. At last, the shortest path is the unidirectional expanding node's set.

Algorithm description:

Create two queues: c: array [0….1, 1…maxn] of jid, it express forward and reverse search expansion of the queue

Create two head pointers: head:array [0..1] of integer, it express forward and reverse search head pointer of the node that will expand in current

Create two tail pointers: tail:array [0..1] of integer, it express forward and reverse search rear pointers

The main program:

Select the expansion direction that the node numbers fewer; the queue is not empty and full.

```
if (tail[0]<=tail[1]) and
not((head[0]>=tail[0])or(tail[0]>=maxn)) then expand(0);
if (tail[1]<=tail[0]) and
not((head[1]>=tail[1])or(tail[1]>=maxn)) then expand(1);
If a certain direction search terminated, continue to the other
direction of the search, until two directions are terminated.
if not((head[0]>=tail[0])or(tail[0]>=maxn)) then expand(0);
if not((head[1]>=tail[1])or(tail[1]>=maxn)) then expand(1);
Until ((head[0]>=tail[0])or(tail[0]>=maxn)) And
((head[1]>=tail[1])or(tail[1]>=maxn))
```

The experiments prove that compare bidirectional search with unidirectional search, expanding nodes reduce at least 1/2. In the project we using the adjacency list to store graph and using bidirectional search algorithm can greatly reduce the storage space and the time complexity of the algorithm.

172.3.3 One-Way Road Solution

In the method we did not consider the actual traffic restrictions, such as one-way road prohibitions. In the classical Dijkstra algorithm, one way road prohibitions is solved by evaluation the infinite edge in the adjacency matrix. The storage structure of the improved algorithm is not the adjacency matrix, therefore cannot use the method of evaluation the infinite edge to solve the problem. There is also used as a directed graph storage segment information, two-way road sections use two endpoints, opposite to the direction of the arcs represent (Peng et al. 2002). But this method repeat storage the road information, waste of storage space, and also affect the algorithm's efficiency.

Because of using the adjacent table storage structure, it stored the information of the nodes, the edges and the weight, but it does not store the information of travelling direction. We increase the judgment information of one-way road in the storage structure. We add Direct field in the node information, which can store the information of travelling direction. We use 0 for two-way road, 1 for one-way road of forward direction and -1 for one-way road of reverse direction. We solve the one-way road prohibition by the storage structure before the algorithm performed, so it doesn't produce any influence to the algorithm. It not increases the time complexity.

172.3.4 Experiment and Result Analysis

In order to verify the feasibility of the algorithm, we search the shortest path of the part of Changchun map using the Dijstra algorithm and improved bidirectional search. In the process of search, we search is the main road of the Changchun city, ignore a few small alleys. The following Fig. 172.2 is part of Changchun city map that stored 189 nodes and 567 arcs. To the same source node and destination node search the shortest path, two kinds of algorithm search the node numbers and the time as shown in Table 172.1.

Fig. 172.2 Part of the road net in Changchun

Table 172.1 Comparison of algorithms

Test times	Dijstra		Improved algorithm	
	Node number	Time/s	Node number	Time/s
1	79	0.27	23	0.08
2	103	0.43	56	0.12

172.4 Conclusion

In this paper, we use the storage structure of the adjacency list, and improve the bidirectional search algorithm on the base of the topological structure and we solve the problem that one-way road prohibitions of actual traffic restrictions. Experiments show that this algorithm may not always be an optimal solution, but the analysis results show that the improved algorithm can overcome the deficiency of the previous methods, and can well be applied to Intelligent Transport System.

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Chapter 173
Review-Based Personalized Recommendation System in Emergency Management

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Abstract In emergency management, it is important to distribute supplies to people that meet their needs and interests. A good personalized recommendation system must rely on users' real interests. Relied on purchase history, overall ratings and other forms of data, which are far from enough to infer users' real interests, the limitation of traditional recommendation methods are revealed. In this paper, we proposed a review-based personalized recommendation system which could be applied in various areas, especially in emergency management. This method extracts a user's latent interest and preference from his/her reviews of a product. The system aims to mine the features of the product which the users paid the most attention to, then find user group that shares similar interest, finally recommend the products that can most satisfy the users' (or decision makers') needs. An experiment was conducted and the result demonstrated that our system could generate a reliable and realistic recommendation.

Keywords Emergency management · Opinion mining · Personalized recommendation · Product reviews

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173.1 Introduction

With the rapid development of Web 2.0, consumers can now post reviews of products at E-commerce (EC) websites. These reviews are useful to both potential users for making informed decisions and suppliers for improving their services (Liu 2011). Due to the diversity mass of online product reviews, it is difficult and time-consuming for a customer to go through all relevant reviews and make a comprehensive decision with the support of them, especially in some emergency cases (Dave et al. 2003).

The EC websites usually recommend best-selling products according to users' browsing history and overall scoring, but it is based on the analysis at the overall product level without considering each user's personalized characters. For this purpose, we proposed a review-based personalized recommendation system (Mahmood and Ricci 2009). The system will obtain the consumers' interests in products features through the analysis of users' online reviews and achieve the personalized recommendation by refining user preference to the specific characteristics level of products. The proposed model integrates collaborative filtering, opinion mining and natural language processing technology and also can be applied in various areas such as emergency management to make decisions, e.g. choosing the most suitable supply, emergency shelter and the most urgent relief materials which are in shortage (Peng et al. 2011). The contributions of this paper are:

1. Different from traditional methods, the proposed system combines recommendation with opinion mining technology and analyzes users' preference at product feature level.
2. The proposed system promotes the accuracy of recommending and overcomes the weakness of lacking relevance between commodities.
3. User similarity is computed based on users' feature preference, so it can avoid the problems of cold start and sparse data to a certain extent.

The rest parts are organized as follows: Sect. 173.2 is the related work of research literatures and the Review-based Recommendation is described in Sect. 173.3, then the experiment is conducted in Sects. 173.4 and 173.5 makes a conclusion to this paper.

173.2 Related Work

Nowadays the most popular recommendation methods can be grouped into 3 classes (Adomavicius and Tuzhilin 2005): content-based recommendations (Mooney and Roy 2000), collaborative filtering (Zhou and Luo 2009) and hybrid recommendation. They rely on customers' searching behavior and purchasing record (browsing behavior, purchasing log, rating, buying and clicking for each commodity item, etc.) (Jannach et al. 2010) to obtain consumers' latent preferences, then try to give recommendations matching with he/she's profile. But only this implicit information is far from enough, all of them ignore customer reviews, which can most directly reflect the information of a user's real preferences (Wang et al. 2010).

In the area of mining customer opinions of products, online customer reviews of products are represented through a set of key words first. After Liu et al. (2005) studied the problem of product feature extraction and generating feature-based summaries of products sold online, how to get product feature words has become a hot spot. Some researchers want to refine the recommendation to users in this way, e.g. Sung-Shun Weng (2004) proposes an E-commerce recommendation system that analyzes consumers' consumption behavior for prediction (Weng and Liu 2004). Li Feng et al. (2007) takes the web page of goods as objects, and recommends commodities with PageRank or emotional classification methods (Jannach et al. 2010). Hu and Liu (2004) presented an opinion summarization system for mining and summarizing feature-based product reviewed (Hu and Liu 2004). A comprehensive discussion of opinion mining and feature extraction techniques can be found at Pang and Lee (2008).

173.3 Review-Based Recommendation

In the applications of recommendation, most systems provide functions of overall scoring and online reviewing after purchasing products for users. These comments contain quite a lot of interesting information, such as some features the user cares and their preferences on them, so we can do some recommendation work to support decision making in various areas such as emergency management with theses information. Our personalized recommendation task aims at automatic extraction of a customer's preference from reviews and recommending products that may satisfy the interest to a single user. The basic idea is that users always pay more attention on the features that they care the most when making purchasing decisions and reviewing, so we could assume that a commodity feature with large quantity of comments is the potential one which will be cared by current user and a feature entity of the product.

173.3.1 Problem Definition

In this section, we first denote the problem. The repositories have 3 components: (1) user-item model, (2), user-feature model (3) item-feature model.

(1) *User-item model*

User-item (Adomavicius and Kwon 2007) is the most common matrix which stores user ratings for each item. For user-i, user-item is defined as $R_{m\times n} = \{R_{ij} \in R|1 \le i \le m, 1 \le \mathrm{j} \le \mathrm{n}\}$, where R_{ij} stands for rating of item-j given by user-i. $U_m = \{\ u_1, u_2, \ldots, u_m\}$, $I_N = \{\ i_1, i_2, \ldots, i_N\}$.

(2) *User-feature model*

User-feature describes all the features appeared in a certain user's reviews, from which we can infer this user's interests then identify his/her neighbors sharing similar interests.

$$UF_{i\times p} = \{UF_{ik} \in UF|1 \le i \le m, 1 \le k \le p\} \tag{173.1}$$

where UF_{ij} stands for feature rating of feature-k by user-i, p stands for feature number.

(3) *Item-feature model*

Item features not only contain features extracted from reviews but also contains product ontology. In our experiment we only take user features into account. All features of a certain kind of item are represented as $F = \{f_1,\ f_2, \ldots, f_p\}$.

173.3.2 Review-Based Recommendation Procedure

This paper proposed a new hybrid recommendation method based on online product reviews. Fig. 173.1 shows the structure. To address the issue above we have explored a hybrid collaborative filtering method by combining item-based and user-based collaborative filtering together. A detailed procedure is as follows:

Step 1*: data preprocessing, gather user set, item set, overall ratings*
This step generally contains stemming, stop-word pruning, etc., then gathers basic information about all the users, items, and ratings for the next step.
Step 2*: product feature extraction*
All item features are extracted, at the same time we obtain the features reviewed by each user.
Step 3*: generate the user-feature matrix UF*
UF records the overall rating for each user, and UF_{ij} summaries the reviews that user-i gives to feature-j.
Step 4*: generate the preference matrix C of the commodity features*

The preference matrix is calculated by TF-IDF algorithm. TF-IDF is the most well-known weighting scheme, in which TF stands for Term Frequency and IDF the Inverse Document Frequency. To a certain user i, each feature he/she weights is the feature j's TF-IDF value in user-i's reviews.

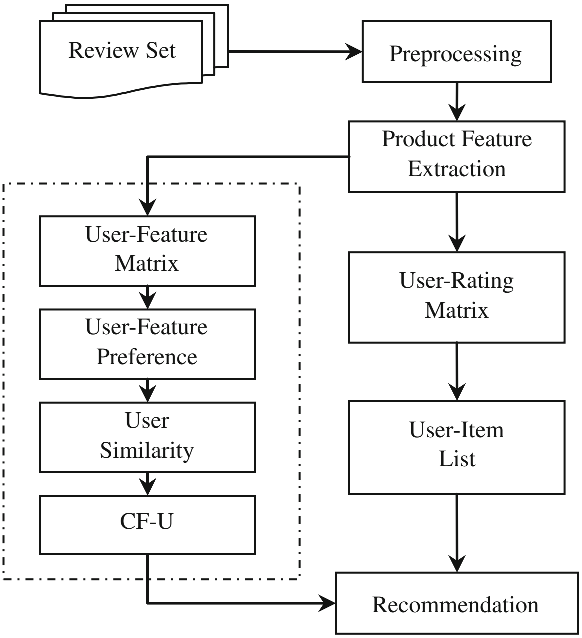

Fig. 173.1 Procedure for the method

Let N be user-i's total number of reviews and df_i the number of reviews in which feature i appears at least once. Let f_{ij} be the raw frequency count of feature i in review d_j. Then, the normalized tf_{ij} and idf_i of feature i in d_j is given by

$$tf_{ij} = \frac{f_{ij}}{\max\{f_{1j}, f_{2j}, \ldots, f_{|V|j}\}} \tag{173.2}$$

$$idf_i = \log \frac{N}{df_i} \tag{173.3}$$

The intuition here is that if a term appears in a large number of documents in the collection, it is probably not important or not discriminative. The final term weight C_{ij} is given by:

$$C_{ij} = tf_{ij} \times idf_i \tag{173.4}$$

Step 5*: calculate user-similarity*

According to C, it's convenient to find similar users by computing *Pearson correlation coefficient* and select the top-k users as the neighbors of the current user;

$$sim(i,\ j) = \frac{\sum_{k=1}^{n} (C_{i,\,k} - \overline{C_i})(C_{j,\,k} - \overline{C_j})}{\sqrt{\sum_{p=1}^{n} \left(C_{i,\,p} - \overline{C_i}\right)^2} \sqrt{\sum_{q=1}^{n} (C_{j,\,q} - \overline{C_j})^2}} \tag{173.5}$$

If users have the same amount of features, user similarity can be calculated with cosine similarity method, the formulation is as follows:

$$sim(i,\ j) = \cos(i,\ j) = \frac{c_i \times c_j}{\|c_i\|^2 \times \|c_j\|^2} = \frac{\sum_{k=1}^{n} c_{ik} c_{jk}}{\sqrt{\sum_{p=1}^{n} c_{ip}^2} \sqrt{\sum_{q=1}^{n} c_{jq}^2}} \tag{173.6}$$

Only the top-k similar users will be regarded as the neighbors of current user and the commodities with high scores would be recommended to user.

***Step 6**: generate user-item matrix R*

In this step, we take user-item matrix as the total scoring matrix R.

$$R_{m \times n} = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ & \ddots & \\ r_{m1} & & r_{mn} \end{bmatrix} \tag{173.7}$$

***Step 7**: infer recommend score*

Predict the score of commodities that haven't been purchased by the current user, and recommend the top-p products to him/her. At last output the most probable interesting items for user u.

User-i's predict rating is:

$$p_{u,s} = \overline{r_u} + \frac{\sum_{u' \in U'} sim(u, u') \times \left(r_{u',s} - \overline{r_{u'}}\right)}{\sum_{u' \in U'} sim(u, u')} \tag{173.8}$$

where $p_{u,s}$ is the prediction of the score that user u gives to product s, and $r_{u',s}$ means the real score that a neighbor user u' gives to product s, U is set of neighbors, $\overline{r_u}$ and $\overline{r_{u'}}$ are mean scores that user u and his/her neighbors give to all the goods respectively. Afterwards, all the alternative commodities will be ranked and the top-k products should be recommended.

173.4 Experimental Study

In our experiments, we will use the data which contains 235,793 comments in a month from 2009-2-14 to 2009-3-15 that was collected by *TripAdvisor* (Datasets are collected by Hongning Wang et al. (Liu 2011)). For data pre-processing, we have used the following technologies: (1) upper case is folded to lower case, (2) remove the punctuation, stop words and infrequent words (<5), (3) stemming with porter stemmer.

In the step of feature extraction, we choose a group of seed words artificially and obtain relative features with bootstrapping algorithm. We set the selection threshold $p = 5$ and iteration step limit $I = 10$ in our experiments. Table 173.1 shows the initial aspect terms used.

After these steps, reviews irrelevant are filtered out, leaving 108,891 pieces about 1,850 hotels, from which we randomly select 1,000 users and their respective reviews.

From review perspective, traditional recommendation methods could hardly make use of text data. Besides, due to the huge mass of products and customers, rating data can be too sparse to find user group. So it's hard to compare our method with traditional recommendation systems. But this method is more applicable in B2C and C2C websites, such as *taobao.com,* as well as distributing supplies during emergency (Table 173.2).

As our experiment focuses on predict rating of recommended items, Mean Absolute Error (*MAE*) (Herlocker et al. 2004), which measures the average absolute deviation between our predict rating and the user's real overall rating, is just right to measure our efficient. Here we define $k = 5, 7, 10$ to check the result (Table 173.3).

From the table above it is obviously that when $k = 5$ we get the best result. This is because we selected the most similar neighbors between whom they share the most interest. When $k = 10$, we also get a satisfying result, lower than when $k = 7$, this due to more information. In business application, due to huge user group, sometimes it proved much better and faster to select several most similar friends.

Table 173.1 Aspect seed words (Liu 2011)

Aspects	Seed words
Value	Value, price, quality, worth
Room	Room, suite, view, bed
Location	Location, traffic, minute, restaurant
Cleanliness	Clean, dirty, maintain, smell
Check in/Front Desk	Stuff, check, help, reservation
Service	Service, food, breakfast, buffet
Business Service	Business, center, computer, internet

Table 173.2 Predicted rating at different k

Hotel_ID	User	True Rating	K = 5	K = 7	K = 10
618542	Blaize76	5	4	4.2	4.2
	Circuitboitravel	5	5	5	5
74806	Boeing767	4	4	4	3.5
	Blaize76	4	4	4	3.6
	Scottca075	3	4	4	4
256659	Harvsman	4	3.8	3.8	3.8
	Boeing767	4	4	4	4
81444	Amy77385	4	4.7	4.7	4.7

Table 173.3 *MAE* at different *k*

k	k = 5	k = 7	k = 10
MAE	0.554	0.572	0.558

173.5 Conclusion

Customer reviews of products represent valuable information for potential users and product suppliers to make best decisions. Due to the huge volume and the unstructured format of product reviews, it is difficult and time-consuming to manually go through all relevant reviews and make a comprehensive evaluation of competing products. During the past decade, opinion mining has been developed to automate the process of extracting subjective sentiments from online reviews, blogs, discussions, and other opinion-related sources, but has not been used to make product recommendation.

This work focused on mining customer opinions from product feature perspective. Since consumer opinions of products are normally expressed using several key product features, we consider customers are more interested in features they frequently commented. On the basis of feature interest, we find similar customers and make recommendations that fit to their preferences. Besides, the system may be used to support fast decisions in some emergency cases such as choosing suppliers or relief materials. An experiment was designed to validate our proposed method using a hotel review set from *TripAdvisor*. The results demonstrate that our approach can generate a reliable and realistic recommendation.

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Chapter 174
The Application Research of Smarter Tourism Management Platform Based on Cloud Computing

Zhu Zhu and You-shi He

Abstract Mass data storage and processing, openness, centralized and unified management are demanded during the process of tourism informationization in the future. On the analysis of requirements of smarter tourism management and features of cloud computing, this paper mainly introduces the structure and function characteristics of smarter tourism management platform based on cloud computing, which provided the theory evidence and operable demonstration for tourism intellectualization.

Keywords Cloud computing · Management platform · Smarter tourism

174.1 Introduction

Early 2009, Sam Palmisano, chief executive of IBM first proposed the concept of "smarter planet". The core concept is to change the interactive way among the government, enterprises and people in a much smarter mode by using new generation of information technology, in order to improve the clarity, efficiency, response speed and flexibility of the interaction (Wen and Shi 2010). Today, with the perfect combination of information infrastructure and highly integrated infrastructure, the government, enterprises and people are able to make wiser decision. Wisdom is mainly characterized by the following three aspects: more thorough perception, more comprehensive connection and deeper intelligence (Chen 2010).

Smarter tourism, derived from "smarter planet", will make good use of the tourist resources of the whole country through the "smarter" tourism management platform to realize the intensification intellectualization and unionization of the

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tourism management. It can improve the government's decision-making capability for the scattered tourism resources and expand the service fields involved by tourism (Liu 2010a). Led by tourism, related industries develop jointly including "transport, touring, lodging, food, shopping and entertainment". Tourism will be fostered as a strategic pillar industry of our national economy and a more satisfactory modern service industry.

174.2 Concept of Cloud Computing and Features of Its Platform

Cloud computing is a web-based virtualization resource platform and a dynamic data center formed under a new IT architectural model (Chen and Deng 2009). It is the comprehensive development of parallel computing, pervasive computing, distributed computing and grid computing; and the fusion of computer technology and network technology, such as virtualization, Internet, network storage, automation management, load balance, etc. It gathers vast resources based on the Internet with the technology of dynamic allocation, cooperative accessing and load balance etc., distributes computing tasks to resource pools constituted by lots of computers to provide users for information service of super computing power, mass storage space and convenience.

Cloud computing is a commercial calculation model, in which users are able to make full use of optimized hardware, software and network resources through the website and obtain more innovative services (Zhang et al. 2010).

According to the research status, cloud-computing platform has three features as follows.

174.2.1 Uniform Management and Service on Demand

Cloud computing platform manages different resources and services uniformly, which is convenient for the user to perceive, inquire and use. Users can choose various services as required, without concerning the location, performance, and fault of resources and services (Liu 2010b; Xiong and Perros 2009).

174.2.2 Dynamic Allocation and Flexible Zoom

Distributed computing resources are integrated intelligently, managed uniformly and allocated dynamically to realize highly flexible zoom and optimum usage. Users need not concern the specific operational process.

174.2.3 Shared Resources and Convenient Use

It provides methods of all computing resources that terminal users use universally, integratedly and conveniently, and man machine interface as well.

174.3 Cloud Computing Features in Smarter Tourism Management Platform

Cloud computing is a virtualized computer resource pool and a new pattern of provision of IT resources. It provides users via network for data, application and other resources by means of service (Amazon Web Services). Computers in its data center composed of hardware, software, etc. can manage and dynamically distribute, arrange, configure, redistribute and recycle resources. Technology of cloud computing will sustain smarter tourism management platform from three aspects as follows.

174.3.1 Mass Data Storage and Processing

Tourism embraces six industry elements—transport, touring, lodging, food, shopping and entertainment, which involve 29 economic departments and affect directly or indirectly 109 segment trades. Tourist consumption not only pulls demand of traditional industries such as civil aviation, railway, highway, commerce, hotels, etc., but greatly accelerates the development of some new-type and modern service industries such as international finance, warehouse logistics, information consultation, cultural creation, conferences and exhibitions, etc. Meanwhile, all sorts of related information gather to produce mass data information. It's an arduous and complicated task for us to transmit, store, process mass data information safely, reliably and efficiently; and on the basis of it, to make right decisions and rational deployment to meet the different demands of tourists, enterprises involved and the government by effective analysis and processing. Therefore, the application of cloud computing is able to store mass data and have super computing power to meet the demands of data platform, on which data exchange, transmission and storage are high-speed, credible, easily expanding and processing.

174.3.2 Openness

With the development of informationization of tourism, its extent and scope will be further enlarged. The platform is required to be able to expand dynamic resources resiliently to handle the changes of resource demand. Therefore, cloud computing can be used to realize the resilient expansion (including resources in related fields) and the dynamic and intellective deployment of resources (Kim 2009).

174.3.3 Centralized and Unified Management

At present, tourists acquire tourism information mainly from Ctrip.com, 17u.cn, Baidu.com, Sohu.com, Qunar.com, Cthy.com and some local tourism information web sites, etc. In general, tourism promotion and marketing dissever comparatively. A unified management platform is lacking which can realize the interflow, coordination and visualization of tourism information (Aymerich et al. 2008). The application of cloud computing is able to process and distribute unifiedly computation, storage and network resources and synchronize the standardization with automation in resource management of tourism industry. It will excavate deeply all sorts of data information integrated by the platform to realize the intellectual decision and control and personalized service.

Based on computing cloud technology, Smart Tourism Management Platform can realize intensification, intellectualization and utility of tourism in many aspects.

174.4 The Conceiving of Smarter Tourism Management Platform

We name the operating and supporting platform Smarter Tourism Management Platform, which can switch on various application terminals sensor nodes dynamically and extensibly, integrate different types of service network and provide foundation application services such as smarter marketing, smarter tour guide, smarter shopping guide, clearing trade transaction, smarter management of scenic spots and information resources, etc., and value-added application service for other industries related to tourism as well; meanwhile it can offer open services on platform support to those travel enterprises involved. Figure 174.1 is the structure model chart of Smarter Tourism Management Platform.

174.4.1 Comprehensive Perception

Tridimensional perception system of Smarter Tourism Management Platform will be constructed by using various sensor technologies and deploying different sensor nodes in capillary microcirculation network to meet the applied demands of

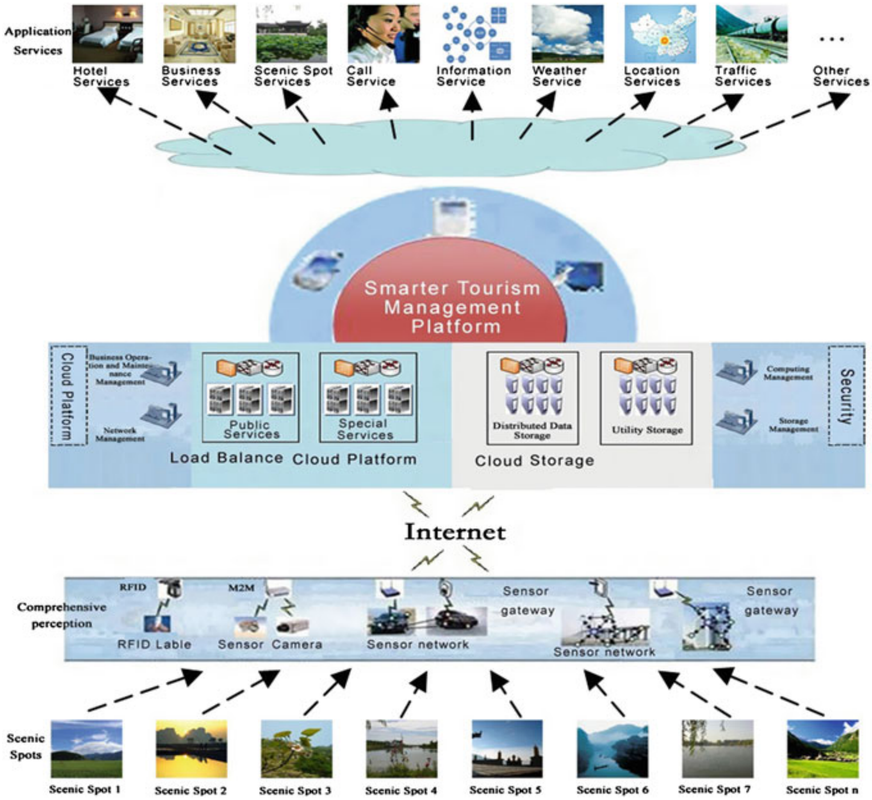

Fig. 174.1 Structure model of smarter tourism management platform

different scenic spots. The platform will inosculate transport, touring, lodging, food, shopping and entertainment as a whole, from the choice of tourist destination to the journey, and other segments related to tourism (Daoud and Kharma 2008). It is based on geographic information, technology of the Internet of things and relies on the internet, sensors, RFID, Zigbee, bluetooth and sensor network to realize the comprehensive perception of online communications (Liu and Yang 2009).

174.4.2 Construction of Cloud Platform

Cloud platform model is the shoring of foundation of Smarter Tourism Management Platform. Its bottom layer connects all sorts of sensor information and upper layer supports various application services. In this way configurable network, server, storage, application and service resources can be accessed expeditiously via network on demand. Figure 174.2 is the structure model chart of cloud platform.

There are four layers in Smarter Tourism Management Platform: physical resource layer, virtualized resource layer, management middleware layer and application service layer.

Physical resource layer, composed of server, memory, network facility, database and other software, etc., provides computing power, storage and information service (Gong and Wen 2009).

Virtualized resource layer makes a large number of resources of the same type form some isomorphism resource pools or the one close to isomorphism, such as computing resource pool, data resource pool, network resource pool, etc. The virtualization of resource (including server, memory and network) integrates more physical resources and makes them in a shared platform (Wang 2009a). Users can obtain resources dynamically through sending requests whenever and wherever possible, without understanding the composition of resources.

Management middleware layer is in charge of the management of computing resources, network resources, storage resources and business operation and maintenance, the aim of which is to use cloud resource nodes with balancing load, localize node fault and manage to restore or shield, and monitor service condition. Business operation and maintenance management includes task management and user management. Task management is in charge of executing tasks assigned by users and application, including configuration deploying, task scheduling, assignment executing and management of task life cycle. User management is absolutely essential to cloud computing business mode, which includes offering interactive interface, managing and identifying user status, controlling user passwords and user account, and charging users, etc.

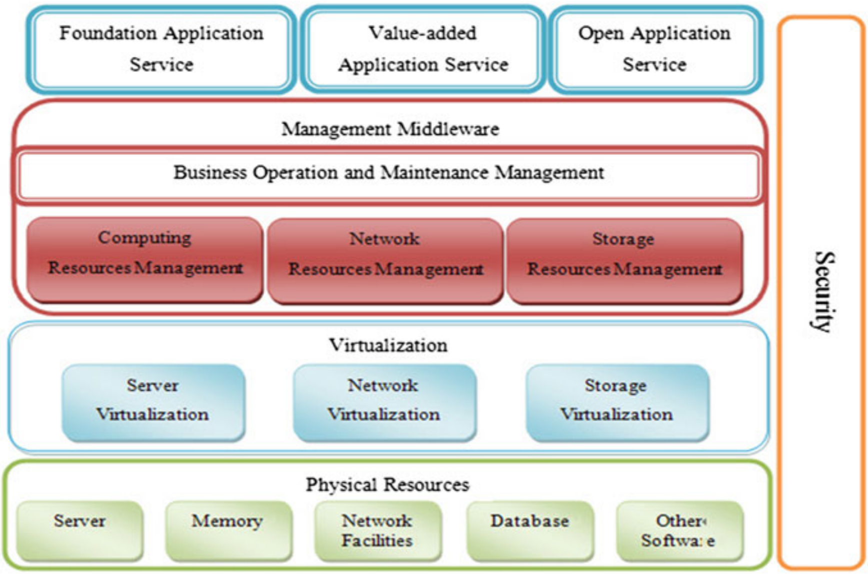

Fig. 174.2 Structure model of cloud platform

Application service layer includes foundation application service, value-added application service and open application service.

174.4.3 Application Service

The application extended by Smarter Tourism Management Platform is divided into three types as followed.

Foundation application services: foundation application closely related to tourism such as smarter marketing of destination, smarter tour guide, smarter shopping guide, clearing trade transaction, uniform service hotlines, smarter management of tourist resorts, smarter trade management, etc.; foundation application services related to tourism such as hotel service, restaurant service, specialty shopping service and recreation facilities service, etc.

Value-added Application Service: application services of trade management by processing sensor data and mining useful data information, such as management recommendation for the government, marketing plans for the sellers, more humanistic service for tourists, etc. in order to form a tridimensional and interconnected tourism application system.

Open Application Services: further expansion of smarter tourism, which offers platform support for kindred or third-party application (Wang 2009b).

174.4.4 Security

Smarter Tourism Management Platform is based on Internet technology and features TCP/IP as transport protocols and browser/WEB as processing mode. It involves flow direction of some data confidentiality and good privacy of users' personal information, such as tour route, consuming habits, location information, health condition, enterprises' product information, etc.; therefore, we should attach importance to its security in designing the platform and reduce security hole as possible for security guarantee of the application platform, its users and Network Operations Center (NOC) (Chen and Zheng 2009).

174.5 The Features of Smarter Tourism Management Platform

Smarter Tourism Management Platform based on cloud computing is the innovation of an applied mode, which has three features as follows.

174.5.1 To Enterprises Related to Tourism

Smarter Tourism Management Platform based on cloud computing provides complete E-commerce service including tourist resort management and monitoring, destination marketing, CRM, design and order of tourist products, etc. to get through B2B channels. It can prompt business communications and increase efficiency of tourism enterprises; provide marketing portals of variant editions, international-oriented and domestic-oriented; lead in third-party financial service or quasi-financial service; integrate mobile payment and e-payment such as citizen card, etc.; construct complete electronic commerce services transaction platform; and be geared to international mainstream payment system.

174.5.2 To Tourists

Smarter Tourism Management Platform based on cloud computing provides all-dimensional public information services for tourists and the other public; offers various service information and trends in good time according to destination theme for an intellectual journey plan; draws support from sensor ending's perception with tourists all over scenic spots to realize smarter service for the whole course; puts to use e-payment including all-purpose card, uses WEB 2.0 technology to set up highly interactive online tourist community and makes the release and communication environment of public information abundant, timely and credible; and integrates social service resources to provide tourists wider information service.

174.5.3 To the Government

Smarter Tourism Management Platform based on cloud computing provides accurate and detailed tourism data for the government and other users. Based on the statistics and analysis of the data, we are able to evaluate tourists' credit and rate those service enterprises for scientific support of the government. Meanwhile, partial expert models are used to make price of tourist products and give a dummy test of tourism industry policies. Taking the market as the orientation, an evaluation system with credibility comes into being by promulgating objective evaluating results of the service enterprises in tourism.

174.6 Conclusion

The application research of smarter tourism management platform based on cloud computing at home and abroad is still at its beginning stage at present. We need to solve the following problems to implement the platform.

174.6.1 Resources Integration

Resources integration is not to duplicate and stack simply all sorts of tourism resources, but to integrate resources and extract valid data on the basis of resources unified management for more humanistic service.

174.6.2 Platform Implement

It is complicated for the smarter tourism management platform based on cloud computing to implement resources integration. Tourism is a scattered, huge system. The course of integration will involve the resources adscription of different departments and the flow direction of final data.

174.6.3 Security

Security is the key issue which constrains the implement of smarter tourism management platform based on cloud computing.

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Chapter 175
Traffic Forecasting at Non-Detector Roads Based on City Road Network

Jian Zhang and Hua Li

Abstract This paper aims to predict the traffic parameters of non-detector roads in a network. The traffic parameter data are collected by a small number of detectors installed on the some of the roads. In a clustering analysis we consider three traffic parameters: traffic volume, average speed and time occupancy ratio. This paper uses the dissimilarity dynamic matrix to process the array data consisting of the above mentioned three dimensions, to obtain the value of traffic parameters of all roads in a regional network. Furthermore, we have chosen a small network in Xi'an to check if this method works. These traffic parameters can be used to predict traffic status to provide the basis for traffic guidance system and the traffic management system.

Keywords Clustering analysis · Detector · Forecasting of traffic parameters · Intelligent transportation systems (ITS)

175.1 Introduction

The forecast of the traffic parameters refers to the prediction of conditions of the target regional transportation system based on known information. It is an important part of intelligent transportation systems (ITS). ITS uses the modern information and communication technology to improve the efficiency of the

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transportation and the traffic network capacity, without expanding the present size of the road network. We can collect information from detector, but there are only less than one-tenth of the roads having detectors installed in China (He et al. 2002). In order to realize the whole network traffic management must have traffic information of these non-detector roads. So the traffic parameter prediction of the non-detector roads is also an important step to realize intelligent traffic. From the previous studies it is found that there exist some correlations between different roads in the same network. So it may be possible to predict traffic parameters of the roads without detectors using the information from the roads with detector.

To predict the traffic status we need three parameters: traffic volume, average speed and time occupancy ratio (Sun et al. 2009; Chang and Chueh 2011; Chen Hong 2009; Wei 2011). There is an increasing need for Artificial Traffic Information Systems (ATIS) and traffic management system (ATMS) to provide road-users and traffic managers with accurate and reliable real time traffic information (van Lint et al. 2005). Feng et al. (2010) developed a method based on the wavelet analysis, and used the BP network to forecast the traffic parameters; Wu (2005) used the method of Artificial Neural Network to predict three parameters of the traffic volume. But that method can only deal with the roads with detectors installed. Xu (2006) studied all roads of a network, including non-detector roads, using the traffic volume parameter to forecast the information of non-detector roads. So the clustering analysis result may not be accurate, for a small volume it may be attributed to two possible reasons: fewer vehicles through the road; little vehicles through due to the congestion of the roads (Li and Fu 2010). Wang (2008) predicted the traffic volume of non-detector intersection using the genetic regression method and has got high accuracy results. However, he only uses one parameter of traffic volume.

This paper mainly aims to predict the traffic parameter of non-detector roads, so as to forecast the whole network's traffic parameter. Clustering with the three parameters, then the author uses discriminant analysis and linear regression method to find the relation between non-detector roads and others.

175.2 Traffic Characteristic Parameters and its Prediction Process

Traffic characteristic parameters are a reflection of the traffic status, the common traffic parameters are: traffic volume, the average speed and density. Usually, we use time occupancy ratio to indicate density. Traffic volume, time occupancy ratio and speed can be used to measure the traffic condition and estimate the travel time.

175.2.1 Three Parameters of the Traffic

(a) Traffic volume

Traffic volume refers to the number of vehicles through the road in a fixed period of time; it varies in time and space. The traffic demand is considered stable for a certain city network. Traffic volume reflects the traffic demands of a certain place and the trend of the characteristics change with time and space. But has certain limitation in the judgment of traffic condition, because the same flow can be corresponding two traffic condition.

(b) Time occupancy ratio

Time occupancy ratio refers the accumulation of vehicle through time and time interval ratios. It reflects the status of the traffic. Higher time occupancy ratio indicates a good condition. There exist certain relationship between time occupancy ratio and traffic volume, known the average speed and average vehicle length, the two parameters can be expressed by the other, but influenced by the signal timing, it is difficult to respond to the current traffic condition independently. Using the parameters of time occupancy ratio and traffic volume can estimate traffic conditions.

(c) Speed

Speed refers the speed of the vehicle when going through the monitoring point. In this paper it is the average speed. In the year 2002, Ministry of Public Security Issued "the index system of urban traffic management" which divided the traffic condition into four levels: clear, mild crowded, crowded, serious crowded:

(1) clear: average speed $>$;
(2) mild crowded: $>$ average speed;
(3) crowded: $>$ average speed;
(4) serious crowded: average speed $<$.

175.2.2 Prediction Process of Non-Detector Roads

Travel time and road status provides a basis for traffic guidance system and traffic monitoring system. Travel time and road state provides a basis for traffic guidance system and traffic monitoring system. When predicting traffic condition of the network, traffic information of all roads is required. So in this paper we use the known traffic information of detector roads to predict the non-detector roads of the network, and use clustering analysis and discriminant analysis to find the quantitative relationship between them. The forecasting process as Fig. 175.1 (Peters and Weber 2012).

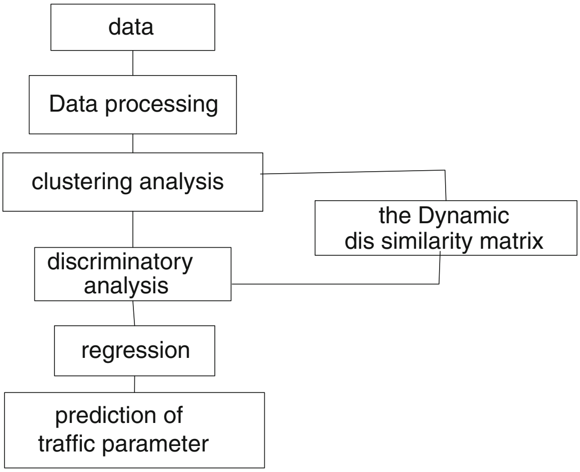


Fig. 175.1 Forecasting process

175.3 Data Processing and Methods Analysis

175.3.1 Data Processing

(a) Original data

In this paper, each road has the traffic parameters of traffic volume, speed and time occupancy ratio. So our object is the establishment of three-dimensional array data (roads × time × parameters) (Sun 2010). In the specific research, the data of planarity form Table 175.1. The letter P represents road name, $p = 1,\ldots, 16$; M represents traffic parameter, $m = 1, 2, 3$; T represents the number of the time used in experiments, $t = 1,\ldots, 28$. $\mathbf{X_{mp}}$ is a vector, representing the m parameter of the P road, $\mathbf{X_{mp}}=\left(\mathbf{x_{mp}}(\mathbf{1}), \mathbf{x_{mp}}(\mathbf{2}), \ldots, \mathbf{x_{mp}}(\mathbf{T})\right)$. For the T observations of the same road should be regarded as a whole, so this paper cites dissimilarity dynamic matrix.

(b) Dissimilarity dynamic matrix

To eliminate the influence of different types, this paper standardizes the above data first. It would not impact on the original data. We then separate the original data into M matrix according to the different parameters, and adopt the z-score standardization standardize it separately.

Table 175.1 X-planarity from data

$$\begin{bmatrix} \mathbf{X}-\text{planarity} & 1 & \cdots & p & \cdots & P \\ 1 & \mathbf{X_{11}} & \cdots & \mathbf{X_{1p}} & \cdots & \mathbf{X_{1P}} \\ \vdots & & \vdots & & \vdots & \\ \text{m} & \mathbf{X_{m1}} & \cdots & \mathbf{X_{mp}} & \cdots & \mathbf{X_{mP}} \\ \vdots & & \vdots & & \vdots & \\ M & \mathbf{X_{M1}} & & \mathbf{X_{Mp}} & & \mathbf{X_{MP}} \end{bmatrix}$$

We use $\mathbf{Y_{mp}}$ to represent the original data $\mathbf{X_{mp}}$. Then we use the dissimilarity matrix to measure the sample's similarity (Sun 2010). Here the dissimilarity dynamic matrix definition of roads $\mathbf{Y}_i$, $\mathbf{Y_j}$, $i,j = 1,2\ldots P$, is

$$\Phi_{ij}=\sum_{m=1}^{M}\sum_{t=1}^{T-1}|k_{mt}^{(i)}-k_{mt}^{(j)}| \tag{175.1}$$

$\mathbf{Y_i}=(\mathbf{Y_{1i}},\mathbf{Y_{2i}},\ldots\mathbf{Y_{mi}});\mathbf{Y_{mi}}=(\mathrm{y}_{mi}(1),y_{mi}(2),\ldots,y_{mi}(\mathrm{T}))$, $k_{mt}^{(i)}$ represent increment of the m parameters of road i.

$$k_{mt}^{(i)}=y_{mi}(t+1)-y_{mi}(t)\cdots\cdots \tag{175.2}$$

Expression (175.1) is the overall three parameters dynamic trend difference between two roads, greater value indicate that the two roads of the greater the dissimilarity.

175.3.2 Cluster Analysis

Cluster analysis is an effective generic method for examining multivariate data with the view of clusters of homogeneous observing variations. The object is to divide the target into a relatively small number of clusters (Li et al. 2010), and the entities within the same group are similar to those belonging to different groups. Many different clustering methods have been proposed and we adopt the most widely used hierarchical clustering method in this paper. When clustering, the two roads would be clustered into different classes (Vermunt 2007). Clustering analysis steps are as follows:

(1) Define the distance between the sample, and the distance between the classes and class, in this paper, distance is refer to the Φ_{ij} of dissimilarity dynamic matrix, the distance of different classes is the shortest of all elements in the two classes;
(2) every observation records as a class;
(3) Calculation of the distance between classes, combine the two classes of shortest distance, then the number of minus one, until gather the number of you need.

175.3.3 Discriminant Analysis and Linear Regression

Discriminant analysis is a multivariate statistical analysis method under the conditions of determined classification. It is used to judge which class the target belongs to according to same characteristic values of the samples. Suppose there are T observation period, k known classes $G_1, G_2, \ldots, G_k$; a single observation sample notes, $\mathbf{Y_{mi}}=(y_{mi}(1), y_{mi}(2), \ldots, y_{mi}(\mathrm{T}))$. It belongs to one of the classes, and we have discriminated which one it belongs to. Then we obtain the relationship of traffic parameters through the method of linear regression. The methods to obtain the data of discriminant analysis are artificial count method, floating car method or video, and so on. On the basis of cluster analysis, classified the non-detector roads, The discriminant function is the dynamic dissimilarity matrix.

Get the relationship of traffic parameters through the method of linear regression after discriminant analysis, and then we can use the parameters of detector roads to predict the non- detector roads' information.

175.4 Application of Typical Road Network

We choose part of the main road Fengqing road, Taoyuan road and Laodong road of Xi'an city. Each road has two directions. The topological structure of the research network is shown in Fig. 175.2. We choose the information of February 2, 2012, with a time interval of 15 min and 28 intervals from 06:00 to 13:00 as analyzing data, 20 intervals from 13:00 to 18:00 as checking data.

In order to validate the feasibility of the method in this paper, here we take the road 7 as non-detector road, the other 13 roads of the network as detector roads. When processing, we put all roads clustering together, then deal with the traffic volume, speed, time occupancy ratio parameters of road 7 with regression analysis.

From formula (175.1) and (175.2), the original data of the 14 roads' translate into dissimilarity dynamic matrix, part matrix as shown by Table 175.2.

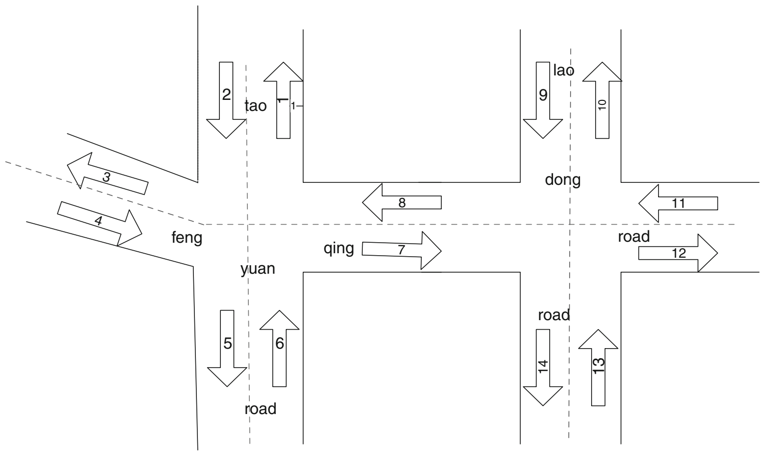


Fig. 175.2 Topological structure of the network

Table 175.2 Dissimilarity dynamic matrix

路段	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0	74.4	84.76	106.8	75.89	101.32	106.2	89.2	89.75	70.4	74.5	73.1	78.1	90
2	74.36	0	78	93.57	78.33	92.52	113.48	78.21	90.27	78.6	77.4	86.4	86.4	102
3	84.76	78	0	96.11	73.31	94.74	104.44	89.13	89.09	84.5	75.1	74	73	91
4	106.75	93.6	96.11	0	87.64	109.03	122.21	101.6	105.24	98.4	94	94.7	99	121
5	75.89	78.3	73.31	87.64	0	85.98	93.55	77.24	76.14	73.7	67.1	65.3	65.5	90
6	101.32	92.5	94.74	109	85.98	0	111.92	90.29	90.57	85.4	90.9	92.2	79.1	113
7	106.2	113	104.4	122.2	93.55	111.92	0	112.4	112.07	109	106	99.7	101	118
8	89.2	78.2	89.13	101.6	77.24	90.29	112.43	0	82.3	68.4	82.8	87.4	70	87
9	89.75	90.3	89.09	105.2	76.14	90.57	112.07	82.3	0	77	74.2	70.4	65.3	97
10	70.39	78.6	84.53	98.4	73.74	85.41	108.63	68.36	76.96	0	72.6	64.3	71.4	77
11	74.47	77.4	75.13	93.96	67.1	90.87	105.75	82.82	74.18	72.6	0	55.2	68.1	94
12	73.08	86.4	74	94.69	65.25	92.22	99.7	87.37	70.39	64.3	55.2	0	64.9	76
13	78.06	86.4	73	99.01	65.49	79.08	101.3	69.99	65.25	71.4	68.1	64.9	0	84
14	90.38	102	91.24	121.2	89.63	112.58	118.46	86.89	96.53	76.9	93.5	75.8	84.1	0

Taking the minimum dissimilarity as clustering standard, the distance classes is maximum distance between two kinds of samples. We use spss software to do clustering analysis.

According to the result, we choose three classes in this paper, the first class is roads 11, 12, 5, 13, 9; the second class is road 8, 10, 1, 2; the third class is 14, 6, 4, 7. This illustrate that road 7 is more similar to class three. So we can predict the traffic parameters of road 7 by the other three roads in the same class. Regression the parameters of traffic volume, average speed, and time occupancy ratio respectively, the three parameters are indicated as $\mathbf{X}_{7,1}$ $\mathbf{X}_{7,2}$ $\mathbf{X}_{7,3}$, and we can get relationship

$$\mathbf{X}_{7,1} = 139.984 + 0.1\,\mathbf{X}_{4,1} + 0.166\,\mathbf{X}_{6,1} - 0.364\,\mathbf{X}_{14,1}$$
$$\mathbf{X}_{7,2} = 10.059 + 0.331\,\mathbf{X}_{4,2} + 0.376\,\mathbf{X}_{6,2} + 0.279\,\mathbf{X}_{14,2}$$
$$\mathbf{X}_{7,3} = 30.213 - 0.617\,\mathbf{X}_{4,3} - 0.055\,\mathbf{X}_{6,3} + 0.226\,\mathbf{X}_{14,3}$$

In order to verify the above prediction results, we choose the data of 13:00–18:00 as proving data, and contrast the predict value with road 7 into the real value of road 7 and road in other classes, as Figs. 175.3, 175.4, 175.5.

'—'is the real value of road 7, '– – –' is the predict value of road 7.

We can see from the three figures that the real value of road 7 has the same trend with road 4 from the same class, but values differentiate largely; it has a different trend with road 5 and road 2 from the different classes, values also differentiate largely. Using the method in this paper, we can get the forecast results of road 7 that has the same trend with its real value and has a small error, or that has different trend and bigger error compared to other roads.

Fig. 175.3 Contrast of traffic volume

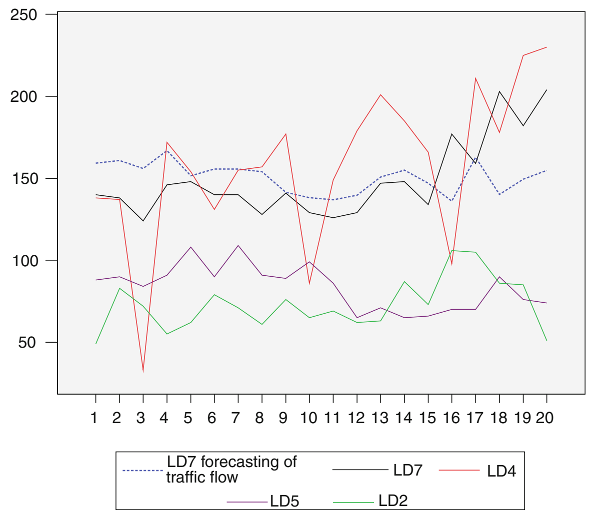


Fig. 175.4 Contrast of average speed

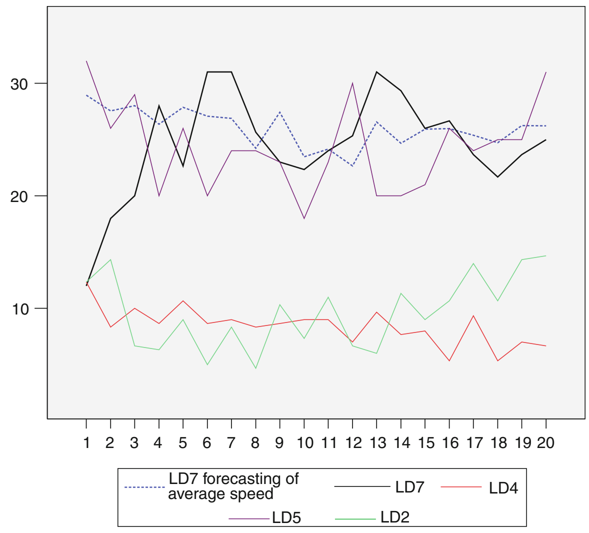
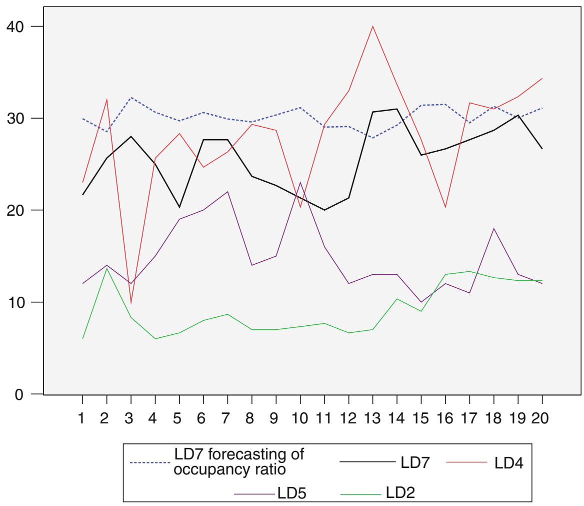


Fig. 175.5 Contrast of occupancy ratio



175.5 Conclusion

In this paper, we have studied the prediction of traffic parameters of non-detector roads, used the data of Xi'an city for analysis and verified with the real data, every road considering three traffic parameters and time factors, This method can also be applied to the similar roads of a bigger network, predicting traffic information more than one non-detector roads. Only using the traffic information parameters of the same class to predict the information with non-detector roads, and when there is also some uncertainty of traffic itself, so to premise the precise, we need to detect the data of non-detector roads manually to revise the model periodically. With these traffic parameters, we can predict travel time, traffic information state and the best signal duration. This provides the basis for traffic service system and traffic management system.

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Chapter 176
Study on Framework and Integrated Optimization of Standard View for Dynamic Management of Complex System

Yang Ping

Abstract The core and essence of the architecture framework is based on a multi-view approach. View approach emphasizes simplify complex issues, from the perspective of different areas to look at a complex problem, a complex problem into a number of relatively independent and simple, the results of each of simple questions to form a view, the view of all the simple questions synthesis, and comprehensive understanding of approximation to the complex problems. With the help of the concept of the standard view, the management of complex systems engineering model to expand the system analysis, modeling based on the standard view of the multi-attribute decision-making in the conditions of the object-oriented theory, based on incomplete information, and on this basis, the integrated optimization for the building standards system.

Keywords Complex system · Dynamic management · Incomplete information · Integrated optimization · Multiple attribute decision making · Object-oriented · Standard view

176.1 Introduction

Along with the high technology especially the information technology make a spurt of progress, a variety of complex systems have been more vast development in aspects of aviation equipment development, large ship design and construction.

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A complex system is a structure in which variables from different scale levels, or a dynamic system in which a large number of elements different from each other. In general, within the complex system there are many subsystems, between which have many synergy, can co-evolution and interdependent. Subsystem will be divided into many levels in engineering practice, and their size varies. Meanwhile, we noted that a variety of subsystems interactive integration, which makes a variety of derivative technology with interface also produce new functional performance and materials technology requirements. These elements are the dynamic development with incomplete information and uncertain environment. So that project management is becoming increasingly difficult.

The standard is a summary of the scientific, technical and practical experience, is the best order in a certain range, is a rule of common and repeated use developed by the actual or potential problems. Technical sense of the standard is a published document form as the unity agreement (De-Yi et al. 1995). Its purpose is to ensure that materials, products, processes and services could meet your needs. In engineering management through the timely formation of the standard, the rational use of standards, effective implementation of the standard, you can optimize resource allocation, active technology element, accelerate the accumulation of technology, ensure product quality, and improve management efficiency. Interaction and integration of various subsystems in the complex system, you need to completely change the situation between systems separated from each other. This requires that we work through the standardization, use systems engineering approach to expand the top-level design, and to form a relatively complete technical system. Thus ensure the completeness of the various elements within the system, the orderly management of the design and the consistency of interface criterion, provide effective support for dynamic management of the whole life cycle of complex systems (Yang Unpublished). This paper expands the system analysis to the management of complex systems engineering model with the help of the concept of the standard view, proposes standard view modeling based on object-oriented theory and multiple attribute decision making with incomplete information (Sa-ru and Ha 2010). On this basis, build a standard system through integrated optimization.

176.2 Concepts and Dimension of Standard View

Zachman (1987) first proposed the description of an information system architecture in “A framework for information systems architecture”, that is the “Zachman framework”. Since then, various areas of development architecture framework, the core and essence are based on a multi-view method. View approach emphasizes to simplify complex questions, to look at a complex problem from the perspective of different areas, make a complex problem into a number of relatively independent and simple questions. The results of each the simple question form a view. All the simple view synthesis, we will get the approximation and comprehensive understanding to the complex problems (Zachman 1987).

The standard view is essentially a standard system composed of a variety of standard elements for different objects at different stages, in the process of dynamic management of the entire complex system. It has the basic attributes of targeted, aggregative, layered, dynamic open and phased (L.Chun-tian in Press). If we have the standard views of the different objects to be integrated, then we can get the standard system of a stage of complex systems at the same time or in the same phase. If for the same object, such as the planning side, the argument side, the designer, developer or contract supplier, etc., we have the standard view of the different stages to be integrated, then we can form standardized requirement or standardized constraint for different objects again, and this is a standard system too. If the final we bring all of the standard view to be integrated, merging overlap, coordinating contradiction, optimizing the redundant part, then we can form a standard system of the entire project management of complex systems (Yang 2011).

Based on the concept of system, we know that the standard view has a unique advantage. It could provide a description of the main line between the various elements throughout the various complex systems, facilitate a comprehensive grasp of the influencing factors on system performance. And it could provide macro guidance for demonstration, development, production and application of all aspects of project management. At the same time, support quantitative analysis and provide a basis for system modeling, simulation and evaluation, and have direct applications to the specific equipment system. With the other architectural views, standard view also needs to define its core elements. These core elements constitute the basic content described by the standard view. It reflects as a definition of a certain view products, which view product extracted from the practical application, to be verified in the application. View product build is based on the core elements in the architecture, is a description of the different angles of these core elements and their relationships, and is the performance combined the core elements with the external form (Zhi—meng et al. 2011). These core elements include provisions of objective, scope, component, functional requirements, performance indicators and test identification in standard, as well as the internal structure of the standard and the standard life cycle.

Based on the above analysis, standard view could be divided into different dimensions according to needs. We will first object the main setting for the first dimension for project management of complex systems, which may include planning, owners, designers, implementers, contractors, etc. Then the project management phase is objected for the second dimension, which may include demonstration, design, development, construction and testing etc. Finally, the elements of the standard within the system would be as a third dimension. The elements within standard system is core-based outreach, and is closely related to its purpose, scope and specific requirements, then it necessarily in close contact with each subsystem and the main components of complex systems. Therefore, this standard view make the main objects of complex systems, the different stages of the engineering and the various subsystems of organic connection within a unified framework and system through a dynamic three-dimensional space (Argote et al. 2003).

176.3 Dimensionality Reduction and Integrated Optimization Method of Standard View

The standard system is a three-dimensional or a high-dimensional space system, the standard view has dimensionality reduction to a relatively simple framework (Boesot 1995). For the standard view and even the framework of the standard system the most effective method is to minimize the dimensions. So, if the different dimensions have different properties, we can use the multi-attribute decision theory to carry out the model work (David and Foray 1995). At present, the multi-attribute decision making problems under complete information is almost complete. However, in complex systems engineering management practice, most of the information has the property of inaccurate, incomplete and vague, coupled with the limitations of managers understanding of the problem or their own lack of knowledge of other reasons, program attribute values and attribute weighting coefficient information which managers are given or acquired is incomplete. Especially a lot of technical and management elements are uncertain, even subject to change at any time (De-Yi 2000). Therefore, based on previous research results, multi-attribute decision-making method is applied to the project management of complex systems with incomplete information (Sa-ru and Ha 2010).

According to the multi-attribute decision making, we can get a particular project phase, a series of standards for different objects of the main view sort. As mentioned earlier, if we view these standards are integrated into together, then due to the different objects at different stages of the assignment of different standard view properties, resulting in the presence of various standard view overlapping, conflicting uncoordinated (De-Yi et al. 2004; De-Yi and Changyu 2004). Therefore, we can, consistent iterative model, making and group decision-making matrix between acceptable similarity of individual decision-making matrix is constantly being adjusted until acceptable similarity between the group decision-making matrix, in order to amend the Multiple Attribute Decision Making matrix (Ying-jun and Dong 2010). Then, the application of factor analysis based on multi-attribute decision-making information, various standard view regroup, to identify common factors affecting the variable, the simplification of data, abandoning the special factor, extract the factor of common standards, which define the standard division, clear standard classification, build standards system (Yang 2011).

Make the main body of the ship impact design object as a reference, for ship impact design project management, assuming that there are six standard views, including that: common basis requirements, test and evaluation requirements, calculation and validation requirements, design criteria requirements, buffer isolation requirements, documents management requirements (Bin et al. 2011). Also have 12 kinds of attributes, respectively as ship universal standard impact test standards, test and environmental standards, analysis of standard, the standard of design criteria, structural design criteria, equipment design standards, piping design criteria, standards of fastening devices, materials, design standards, vibration isolation design standards, data management standard. Suppose there are six grades of

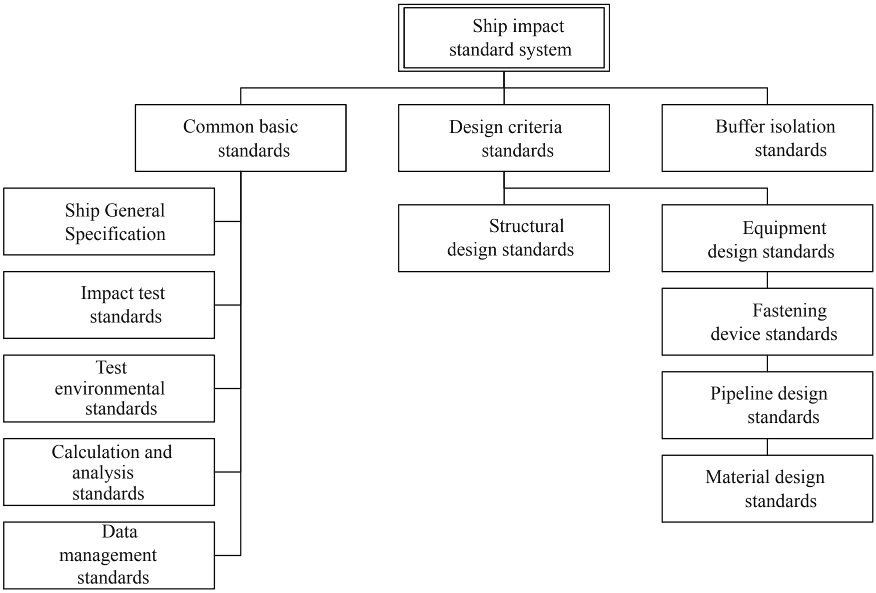

Fig. 176.1 Ship impact standard system

evaluation, based on the previous theoretical analysis, and multi-attribute decision-making, in various stages of design, project management needs to select a different property assignment, the formation of a number of sort of the standard view.

Use principal component analysis method to calculate the correlation coefficient of the ship impact indicators matrix eigenvalues. We can find that the cumulative contribution rate has reached 91.33 % by analyzing the first three common factors, take the first three eigenvalues to establish the matrix of factor loadings for factor rotation. The extracted data is a subset of data that contains only numbers and rotated factor score, and sort according to the three common factors. So integrate multiple standard views, to get the ship impact standard system (see Fig. 176.1) (Yang 2011).

176.4 Conclusion

In the management of complex systems engineering, between the specification of various standards are often interrelated and support each other, while a standard is usually covered by a number of technical indicators, according to the systems and related technologies involved in a technology-by-entry decomposed to establish the standard system, then the bound cannot resolve the correlation between the various subsystems and the technical standards as reflected in the technical requirements which makes the overlap phenomenon in which no line is not only difficult to clearly define the standard system of internal the level of division, an increase of the design and evaluation of the workload, but also seriously affect the standard system of internal coherence, and reduce the practical utility of the standard, and even lead to confusion and errors of the technical design and evaluation. The multi-view approach is to understand, a common way to describe complex things, reflecting the divide and conquer concept.

Standardization issues in the management of complex systems engineering is attributed to incomplete information on multi-attribute decision making problems with interval trust structure, and be optimized by factor analysis to construct the standard system (Ying-jun and Dong 2010). Form of the model is simple and easy to understand, compared with the simple use of cluster analysis and principal component analysis combining model closer to the real, making it easier and more flexible for different objects. Established model in the standardization of large, complex systems research and feasibility studies, to co-ordinate, constraints, and integration of various subsystems, sub-equipment standards, integrity, order and correlation three specific view of the standard requirements standardization of systems and management of real integration, and reduce the technical risks that may result from lack of experience in developing.

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Chapter 177
Metro Project Design and Development of Evaluation System

Ya-dong Fang and Zhong Du

Abstract The subway project decision system is based on analysis and design. This paper introduces the key technologies of the system such as distributing component technology, JavaScript Scripting techniques and CSS technology. Then after the above works, it analyzes feature tree of the system and discusses the system architecture of the system; It focuses on the implementation environment of the system from the client, server-side software and hardware and introduces the key page of the system finally.

Keywords Feature tree · Key technologies · Subway project · System architecture

177.1 Introduction

The iron construction project has a significant impact on the national economy, the cost of subway construction is higher, technical difficulty is more serious and the construction period is longer. It is very difficult for their retransformation and reconstruction due to the complex geology, hydrology and urban forest of the built environment (Mao 2001). So it has a very strong irreversibility. This determines the seriousness and rigor of the metro project decision-making. Underground space has once developed, stratigraphic architecture had not recovered. The built underground structures will impact the development of the Neighboring regions, so subway construction must be under the guidance of a scientific theory and

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method system which contains rational planning, scientific decision-making, management and comprehensive utilization.

For the metro project decision-making evaluation, it can be combined with the analytic hierarchy process and fuzzy mathematical theory to build a subway project decision-making model. On the basis of the analytic hierarchy process and the fuzzy comprehensive evaluation model building process, it studies the general steps and Fuzzy operation principle of Fuzzy comprehensive assessment and determines the multilevel fuzzy model. Finally it verifies the fuzzy decision problem of the metro project by some examples. It realizes the subway project of distributed and collaborative decision-making evaluation of network environment to verify the Scientific and effective of multilevel fuzzy evaluation of subway project (Bahcaared 1975).

177.2 System Features

System business is divided into decision-making project management, project bidding management, project management and systems management four functional modules, also a system administrator, space, project administrator space, bidding enterprise space and user space (Zhao 2009), as detailed below:

(1) Space of the system administrator
The system administrator space included modules are: tender business management, common user management and bulletin boards. Bidding enterprise management and user management verify the delete and query features of the bidding enterprises; Bulletin board management module includes: display of notice and notice to add, delete and change.
(2) Space of project managers
The functional modules of dominant enterprise space including: Project management, information management of the bulletin board, the fuzzy decision of the metro project and the bidding enterprises gray choice. Project management is used to create, modify, delete and publish functions; Bulletin board information management includes bidding information management, announcement information management as well as successful results announced. Metro project fuzzy decision-making module adopting expert evaluation method and using fuzzy mathematical theory determine the subway project is or not. Gray selection module of bidding enterprise basing on the gray relational theory completes the project evaluation work (Xie 2005).
(3) Tender enterprise space
Tender enterprise space contains bulletin board information management and project bidding. Bulletin board information management includes the bidding information management, the publication of the announcement information management and the successful results (Jiang 2007).

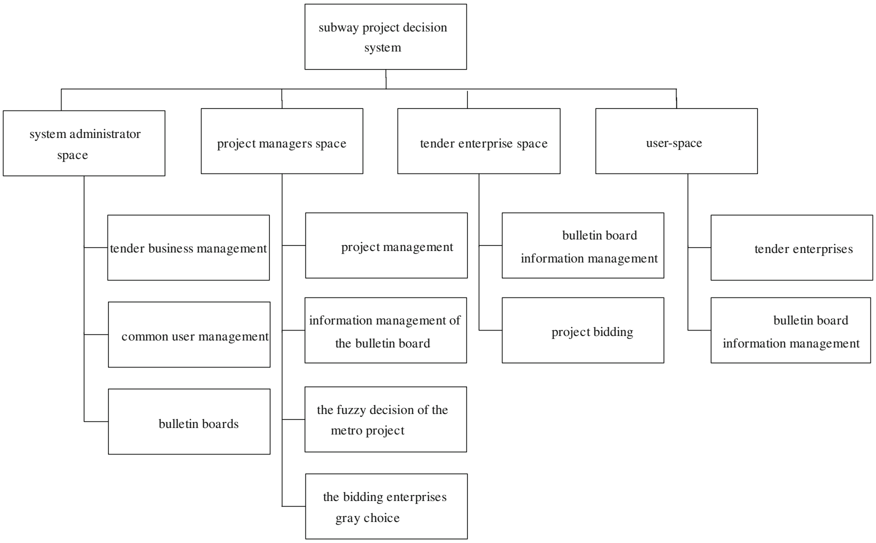

Fig. 177.1 Diagram of system function

(4) User-space
The functional module of ordinary user-space includes tender enterprises as well as bulletin board information management. Bulletin board information management include: the announcement of the successful result and bidding information management (Fig. 177.1).

177.3 System Architecture

At present, Corporate MIS system development has been a large number of Web Server technology stage. Generally it is classified into File/Server, Client/Server and Browser/Server. The overall structure of the system adopts B/S mode (Zhang 2008), Shown in Fig. 177.2.

177.4 Key Technologies

The metro project decision-making evaluation system is based on Java technology, which follows the J2EE specification. It mainly achieves system dynamic page design by the JSP and business (such as server-side database operations and the gray relational algorithm, etc.) by Java Bean. JavaScript mainly achieves data

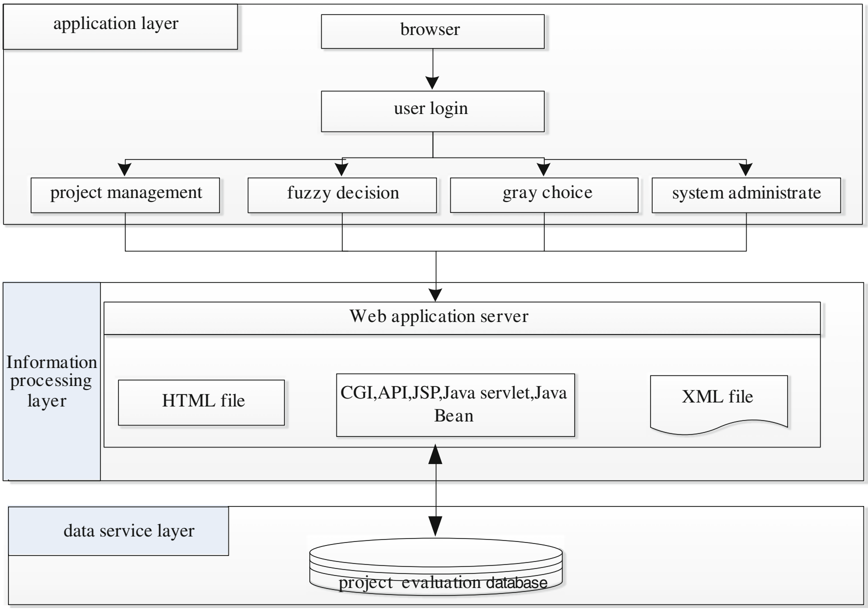

Fig. 177.2 System architecture diagram

constraints (such as the control of the system login page, selecting the form action page is processed, etc.), CSS (Cascading Style Sheet) mainly achieves beautification of the page and its page style modular (Ren and Wang 1998).

177.4.1 Distributed Component Technology

Decision-making selection system of the metro project uses the Java Bean component technology to deal with the critical business. it achieves the client and server-side information exchange by the JSP dynamic page technology. Including in database operations bean (data operation. class), gray associated with bean (Grey relation class) and project fuzzy decision-making bean (fuzzy decision class), and database operation Bean includes the attributes and operations shown in Fig. 177.3 (Ren and Wang 1998). It contains Java Lang, java.io and java.ql. The Java Bean named database operate class in the database operate bag. The class database operate () indicates its constructor. Delete () indicate the ways to delete data, execute Query () indicates the method to query the database, Insert () indicates to insert the database, Update () operates to update the database.

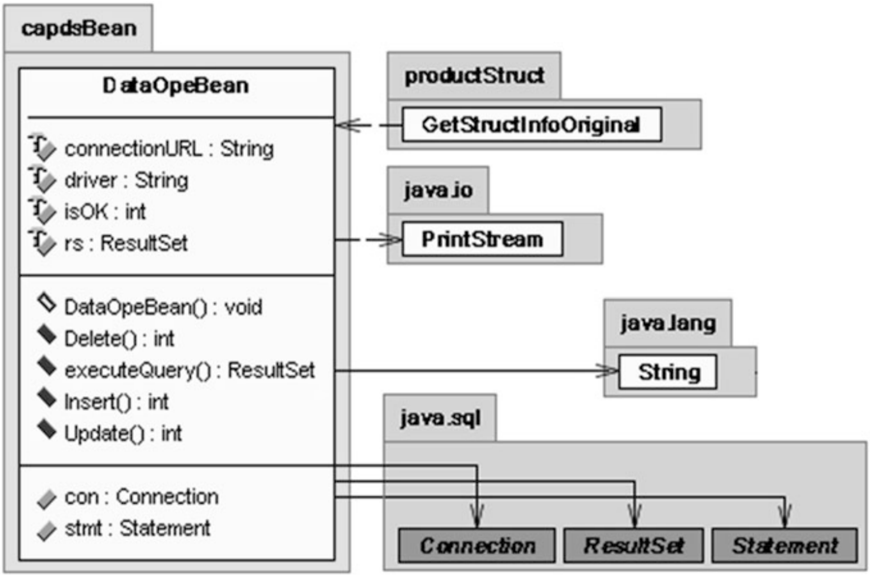

Fig. 177.3 Database operation Bean

177.4.2 JavaScript Scripting Technology

JavaScript is a scripting language based on the object and event-driven and it contains the safety of performance. JavaScript can make the vivid web pages. Its purpose is to multiple objects in a web with HTML and Java scripting language and link with the network client, which can develop client applications. It is achieved by the standard HTML language (Zakas 2012). The judgment of the data type and format in the system are implemented by JavaScript. JavaScript application reflects the two aspects: dealing with the button action and checking data. Some common functions such as edit Project Mgr () indicates to modify the project information, confirm Del () indicates whether the write-off, Del () indicates to cancel (Xia E-j and Su G-l 2003). The code of canceling as follows:

177.5 Interface Design and Implementation

The project interface has Web style, the interaction between user and system is achieved by Web (Hong et al. 2008),so the system as follows:

(1) Inputting information is as little as possible.
(2) Interface is clear and concise.
(3) The user can easily input information through the keyboard or mouse.
(4) User seeing the output interface is intuitive and understanding easily.

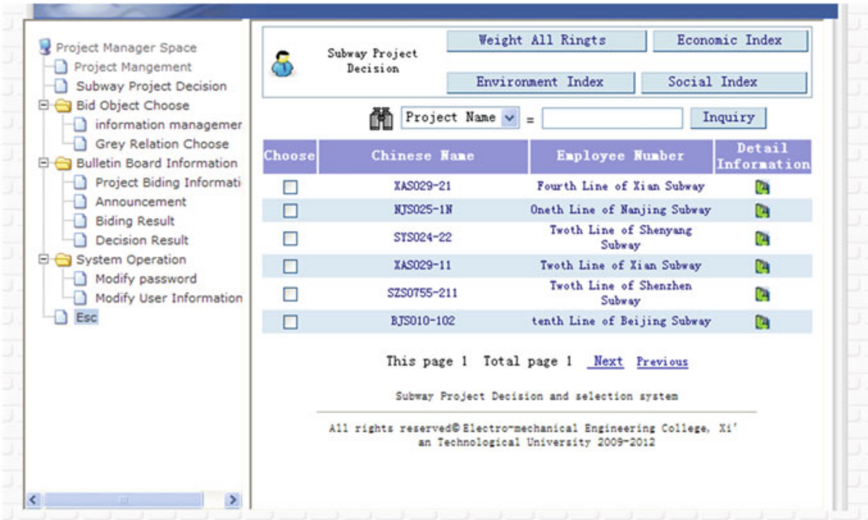

Fig. 177.4 Decision page of the project

In the system design and implementation process, it achieves the design of the JSP page though Dream Weaver, Edit plus. Java Beans is achieved by Jbuilder10. The one of typical pages is Fig. 177.4.

177.6 Conclusions

It analysis the key technologies of the subway project system, and introduces the function tree of the system and software which achieves the system and describes the environment of achieving system from the client, server-side software and hardware. Finally, the key page is given.

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Chapter 178
Analysis of Professional Practice Ability Training of the Student Based on the Extracurricular Activities

Juan Shi and Er-shi Qi

Abstract The professional practice capability is one of the students' comprehensive competences. From the perspective of cultivating students' professional practice capability, this paper probes into the necessity of constructing the platform for Second classroom activities as well as summarizing the construction, approach, and implementing effect of the platform concerning the writer's working experience. This paper is aimed at deepening teaching reform, thus elevating students' professional practice capability and employment competence.

Keywords Practice capability · Second classroom activities · Employment competence

Professor Lu Guoqiang, the expert in English once noted, "The power of knowledge consists not so much in its wide spectrum as in its wide application." Thus the essence of acquiring knowledge is applying it to practice. Having studied English ever since primary school, most of the English majors still have a quite poor command of English, which is due to the fact that they have little access to using it. This circumstance not only militates against improving students' language application ability, but also hinders the overall development of English teaching level in China.

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According to the rules of language learning, only by assimilating enough language materials and undertaking a certain amount of practice can the leaner acquire the ability to use language. It is obvious that it is far from enough to learn from classroom teaching solely. As teachers, they have the responsibility and duty to offer students more chances to practice and apply the language. In accordance to the actual situation of English specialty teaching environment in Chinese colleges and his own working experience, the writer holds the point that it is sensible and effective to develop the second classroom activities. Concerning its implementation in the writer's school over the years, this paper will discuss the thoughts, approaches and achievement of constructing the platform for Second English classroom activities to cultivate students professional practice capabilities.

178.1 The Necessity of Constructing the Platform for Second Classroom Activities Centered on Students Professional Practice Capabilities

Now that neither the teaching hours nor language practice opportunities in English class can meet the need of developing students' language application ability, constructing the platform for Second English classroom activities turns out to be the critical approach to language practice (Cai 2008).

Second classroom refers to a variety of educational activities arranged in an aimed and planned way by universities. As an effective supplement to classroom teaching system, it can provide students with the chance of using English for communication and promote their initiative and learning passion. Guiding and organizing students to participate in English learning and practice during their leisure time overcomes the constraint classroom teaching content and form, and enable students to choose learning content and practice pattern according to their own interest. In the authentic communication scenes, students learn to express their opinion with English and experience its idiomatic usage, and eventually stretch their potential to the fullest. Therefore, the Second English classroom, an indispensible element in the development of students deserves to be implemented premeditatedly and systematically.

Constructing Second English classroom and carrying out various language practice activities can both improve students' English application capabilities and develop their vocational core competence. English application abilities include listening, speaking, reading, writing and translating skills as well those for communication, which requires plenty of practice. Carrying Second English classroom activities with different emphasis and forms for specific sills can effectively develop students' English level and communicative ability, thus strengthening their language application abilities. Meanwhile, by conceiving, negotiating, and communicating in the organization and participation of activities, students are able to realize their potentials, develop their comprehensive qualities and vocational core competence, and accumulate enough experience as a good foundation for future careers in the society.

178.2 The Construction and Implementation of Second Classroom Activities Platform

Considering social development and local economic construction, the school has not only built up Second English classroom system according to the laws of talent cultivation and characteristics of the students, but also established comparatively complete mechanism of second classroom for extracurricular social practice (Han 2006).

To begin with, the school founds a work group of extracurricular social practice for college students, which consists of the leader in charge of student affairs, student counselors, and directors of student clubs. The group members plan and direct the social practice activities as a whole. The Youth League Committee of the school takes the responsibility of leading, designing, directing and organizing the activities, as well as constructing and managing student clubs. The student union and clubs take charge of the implementation of academic and cultural lectures, social practice, recreational and sports activities, and dormitory culture building. Thanks to the clearly defined responsibilities and sound organization, the second classroom system can operate well.

In addition, the second classroom system is of various contents, wide range, and different levels. We carry out the second classroom based on the thought of “do some things, and leave some things undone” to meet the demand of social development and local economic construction. What’s more, we see as our theme the cultivation aim of English specialty as well as the expansion of students’ comprehensive qualities and their creativity. We try to construct the platform of second classroom for college students, guiding more students to take part in the rewarding and beneficial activities of high level. From the practice and experience over the years, we have formed a platform characterized in four categories of moral and ethical development, physical and mental growth, professional qualities, and practical service. Note: the four categories are classified relatively, in which many activities are multi-functional and student-oriented in order to develop their comprehensive qualities. Besides enjoying a sound foundation for their specialty and basic skills, the students should continuously expand and elevate their professional qualities including accumulation of scientific literacy, cultivation of creativity, and improvement of humanistic qualities. As the key part of the activity platform, the above working targets will be emphasized in the following two sections.

178.2.1 The Second Classroom for Professional Qualities

We have always been thinking highly of expanding students' professional qualities. Consequently, we have waged the campaign of "The Week of Quality Expansion" by inviting experts of related areas to introduce the latest trend, specific information and developing prospect of the discipline for the purpose of enlarging students' academic horizon. Furthermore, in order to promote students cultural accomplishment, we have conducted the activity of "Reading Month" to recommend classic works of arts, social science, language and literature, as well as encourage students to write essays and join in reading saloons. In addition, we launched the "College Lecture" composed of "famous teacher lecture", "post graduate lecture" and "undergraduate lecture" for the students to keep up with the newest developing trend of international science and technology and provoke their interest in scientific research (Jiang 2008).

We have adopted several measures to cultivate students' technological innovation by implementing "The Incentive Regulation of Students' Achievements in Scientific Research" and "The Incentive Regulation of College Students Discipline Contests". On one hand, we encourage teacher to instruct students to participate in scientific study and discipline contest by offering rewards to winning instructors; on the other hand, we support students to get involved in scientific projects and the senior to join in the teachers' research groups to orient their study and lay a solid foundation for their thesis. The above mentioned measures have succeeded in developing students' innovation abilities and professional practice capabilities. In the recent years, there have been forty scientific projects undertaken solely by students in our school. 40 % of students have participated in scientific study.

178.2.2 The Second Classroom for Practice Service

Considering our advantage in English specialty, our school, with the establishment of college students clubs, social practice demonstration teams and college students practice squads, has conducted a series of second classroom activities such as those to serve local economic construction and improve students' professional practice capabilities, and those about campus culture and social practice. By doing so, students' innovation ability, language application capability, professional qualities have been strengthened, and their comprehensive qualities and capabilities are developed subsequently.

Our school has initiated and organized student clubs to corporate with enterprises in development zones, communities, elementary and middle school, local service offices for the establishment of social practice and internship bases, which play the role of social service of wide range. Adopting the pattern of integrating key points and general work together, we built up four or five social practice teams in the summer vacation with other students practicing individually. The teams, specializing in the discipline to serve the need of communities and organizations, enable the students to train their language application ability and their awareness of serving the society. In addition, the students have strengthened their skills of analyzing and solving problems as well as widen their horizon.

178.3 The Approaches of Establishing the Platform for Second Classroom Activities

178.3.1 Organizing Wide Range of Activities Covering All Aspects and Angles

As an essential approach to practice and experience English, the second classroom has become a key task in our school. First, we are supposed to better manage the activities of reading English in the morning and listening to campus English broadcasting. Second, we should require English clubs to wage series of extra-curricular activities under the supervision of counselors and instructor, such as spoken English competition, English speaking contest, and recreational activities such as English saloon, English culture festival. What's more, we should continue to improve and enrich the activities to make them distinctive cultural activities on campus (Pang and Wang 2007).

178.3.2 Combining Individual Activities and Group Activities

The Second English classroom activities can be divided into two types: activities for individuals and those for groups.

As to individual activities, counselors are responsible of introducing activity forms and characteristics to students. For instance, students can improve their English listening skills with the help of English radios and English movies, satellite TV shows; or they can improve their oral expression ability by reading, reciting, lecturing, debating and performing. In addition, reading English newspapers and factual books, stories and essays can help them to develop reading comprehension ability, while keeping diaries and delivering reading reports is beneficial for their writing skills. Students can pick activities one by one for their special needs or choose some of them at a time concerning their own interest and demand. During the whole process, teachers only function as directors and supervisors.

Group activities consist of oral English competition or speaking contest, debate, English corner, drama, English evening, etc., which is generally organized by classes, clubs, student unions, and Youth League Committee. There will be one activity every week and one theme every month. In this way, nearly all the students can join in the activities to develop themselves by learning, experiencing and practicing English. Through these activities, students are able to obtain knowledge outside of the classroom and gain interest and confidence of learning English.

178.4 The Effect of Second Classroom Activities

178.4.1 Enhancing Students' Capacities and Qualities

We have attached great importance to cultivating students' English competence in order to improve their listening, speaking, reading, writing and translating skills as well as their comprehensive abilities while conducting the second English Classroom activities. By designing activities, assigning personnel, arranging the site, and operating the activities, the students have gotten profound understanding of the significance of certain abilities for organizing, cooperating, communicating, problem solving, and innovating, as well as the importance of team spirit, which bring great benefit to the improvement of their ethic, professional, cultural, physical and mental quality (Wang and Xiang 2003).

178.4.2 Enriching Students' Extracurricular Life

The English second classroom has not only offered students a platform for English practice, but also a space of good atmosphere for extracurricular study in favor of developing their English application and comprehensive abilities. While taking part in various kinds of activities, the students have learned to arrange their life and study to make their extracurricular life colorful, their mind open and agile, and their capacities in social activities and self-study much advanced. Meanwhile, students are able to adjust their emotion and study strategies besides improving their knowledge and skills with their mind strengthened, their personality displayed, and their intelligence developed. The platform has endowed them with a valuable experience of learning how to study and behave.

178.4.3 Boosting the Effect of English Study

In the second English classroom activities, students manage to develop their English level by mastering knowledge outside of textbooks, getting better acquainted with customs in English speaking countries, building up vocabulary in a comfortable environment. In the large amount of English practice, students can feel the natural English exchange in person and improve the motive and initiative of communication. Besides, their comprehension of language and culture is much deeper, thus makes learning more automatic and active. In a work, the second classroom has played an irreplaceable role in English study (Wen 2009; Dai 2010).

As an extension and supplementation of English study, the second English classroom takes the students as the main body, ability the center, and application the key. Through lots of practice, it enables students to consolidate linguistic knowledge, develop their language application ability, and improve their comprehensive capacities and qualities. During the process, students take the initiative to choose the content and pattern of activities in accordance with their English level. They actively construct knowledge and participate in activities about listening, speaking, reading, writing and translating. As a result, they not only learn, experience and practice English, but also develop their language abilities, awareness of cooperation, communication skills and team spirit. It has been proved that the second English classroom has deepened the linguistic knowledge learned by the students, widened their study range, developed their communication ability and improved tremendously their study efficiency (Zheng 2010; Liu et al. 2010).

178.4.4 Elevating Students' Employment Competence

While arranging the second classroom activities, we have integrated social practice into specialty internship to help students accumulate experience, develop their abilities and strengthen their professional practice capabilities (Shao et al. 2007). Our school had established "internship base" with enterprises, arranging graduating students to undertake specialty-related social practice, which not only enables students to learn about the production, management, operation, culture and concept of the enterprises, but also gives the employers a chance to select talents through long term contact with the students. The second classroom activities have cultivated students' awareness of innovation and competition as well as their interest in the specialty and employment competence. In addition, the close attention paid by enterprises has further inspired the undergraduates' passion for study.

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Chapter 179
The Effect of Entrepreneurial Network on New Venture Growth: The Regulatory Role of Entrepreneurial Learning

Jun-ping Yang, Ting-ting Chen and Lu-bin Tang

Abstract Although entrepreneurial learning is an important mean to transform and utilize the tacit knowledge contained in entrepreneurial network, little research has focused on how different entrepreneurial learning (explorative learning and exploitative learning) would impact the relationship between the two typical entrepreneurial networks (formal network and informal network) effects on the growth performance of new ventures, which resulted that it's unable to guide entrepreneurship practice well. This paper analyzes formal and informal entrepreneurial network's impact on new venture growth performance along with explorative and exploitative entrepreneurial learning's influence on that process. Empirical tests found that both different types of entrepreneurial network and entrepreneurial learning have a positive impact on the growth performance of new ventures, and explorative learning help to the positive impact of formal entrepreneurial network effectively on growth performance of new ventures.

Keywords Entrepreneurial network · Entrepreneurial learning · New venture · Growth performance

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179.1 Introduction

Entrepreneurial network contains a lot of tacit knowledge, which are key factors for new venture existence (Hoang and Antoncic 2003) and growth (Marie et al. 2008). However, the past studies also found that it was not a simple linear relationship between entrepreneurial networks and entrepreneurial performance (Cooper 1994), (Watson 2007), whether entrepreneurial network can promote new venture growth depends on entrepreneurial learning (Susanna and Nicole 2010). Different forms of entrepreneurial learning (explorative learning and exploitative learning) may have different effects on the impact of entrepreneurial network on new venture growth performance, while previous studies pay less attention to it. The past studies regarded the entrepreneurial network as a whole constructs, and ignored its internal structure (Lechner and Dowling 2003). Meanwhile, the theoretical finding for how to balance the two learning types is not yet uniform. In order to explore the difference between explorative learning and exploitative learning in reading and using tacit knowledge, we explore their effects on new venture growth from the perspective of two kinds of network, and put emphasis on different effects under two types of entrepreneurial learning. The results may improve new enterprise growth theory and provide some guidance for enterprise practice.

179.2 Theoretical Analysis and Research Hypotheses

The growth of enterprise can be read by the expansion of business scale, improvement of their overall quality and constantly enhancing in viability and competitiveness. Its essence is the interactive process of the expansion of the organization, accumulation of knowledge and institutional construction. A new enterprise's growth is a dynamic learning process, which depends on the environment, the growth process need to get valuable resources through the network activity, help businesses establish credit, obtain recommendations, and access to information, channels and customers, build a positive corporate image, and promote the implementation of innovative. At last it can improve competitive advantage of the business (Zhao and Aram 1995). Therefore, entrepreneurial learning and networks are important means to help new enterprises overcome the defects of the new entrants (liability of newness), and to promote its rapid growth.

179.2.1 Entrepreneurial Networks and New Venture Growth

Entrepreneurial network has been built during the growth process of new enterprise (Hoang and Antoncic 2003). Former researches indicate that the relationship network can provide support and critical supplement for enterprise decision, and entrepreneurs can get more resources, information and moral support through personal networks (Bratkovic et al. 2009), and the network can also provide rich and effective information which is conducive to the development of new products and the improvement of growth performance (Lavie 2007). There are formal and informal entrepreneurial networks. The specific role of the entrepreneurial network will vary due to the differences in network type. The establishment of formal entrepreneurial network is based on business contacts and interests. Formal entrepreneurial network relays on its organization, including suppliers, competitors, government departments, and intermediaries network relationships. Informal entrepreneurial networks based on trust, which established on the basis of similar background or common language, including friends, colleagues, etc. (Littunen 2000). Information sharing among the members of informal networks can enable enterprises to obtain more reliable information and tacit knowledge. The tight link among the members of the network can enhance the emotion and trust, and thus provide more emotional support for entrepreneurs and key information, in turn, promote the growth performance of new ventures.

Because of the different backgrounds and network relationships among members of formal network existing as a weak link, enterprises can get more heterogeneity information, communication and exchange among suppliers, intermediaries, government departments enable enterprises to gain more business support, which can reduce the risks and uncertainties, make up for the newly created disadvantage, and promote business growth. Based on the above analysis, we hypothesize that:

Hypothesis 1a: Formal entrepreneurial network has a positive impact on the growth of new enterprises (Fig. 179.1).

Hypothesis 1b: Informal entrepreneurial network has a positive impact on the growth of new enterprises.

179.2.2 Entrepreneurial Learning and New Venture Growth

Entrepreneurial learning is a process of accumulating and creating knowledge that related to entrepreneurial activities, it is also the process to better decision-making by using the knowledge (Minniti and Bygrave 2001). Entrepreneurial learning helps new enterprises survive and grow. It also maintains a competitive edge in the fierce competition. It can bring the long-term benefits to the enterprise, and standardized learning contributes to the promotion of internal management capacity.

Learning can be divided into explorative learning and exploitative learning. The nature of exploitative learning is to improve and expand the enterprise's existing technologies and capabilities (Rothaermel and Deeds 2004), while explorative learning can extend the areas of the market and develop new products through new, diverse, non-redundant knowledge. This article holds that exploitative learning is a low-risk way to enhance the technological level and deepen the business operations. Its implementation requires an in-depth understanding rather than a wider field of information, including less adventurous composition. So exploitative learning is a low-risk way to enhance the technological level and deepen the business operations.

While explorative learning is characterized by innovation and risk, its implementation can contribute to product innovation, and enable enterprises to expand the company market share and maintain our competitive edge in the fierce market competition, achieving rapid growth. Based on the above analysis, we propose the following assumptions:

Hypothesis 2a: Exploitative learning has a positive impact on the growth of new enterprises.

Hypothesis 2b: Explorative learning has a positive impact on the growth of new enterprises.

179.2.3 Entrepreneurial Networks, Entrepreneurial Learning and New Venture Growth

The conduct of entrepreneurial activity is carried out in the interaction of entrepreneurs and members of the network. Entrepreneurial learning is the reaction to others' behavior under specific network and entrepreneurial process. According to Schulz (2001), the exploitative learning is a deterministic process as well as a result. Explorative learning is a complementary way that acquire new ideas and innovation from the complex and ever-changing environment. However, accompany with high-yield business, explorative learning also brings high-risk. If enterprise over-reliance on this approach, it may make companies cannot absorb the knowledge that they owned. The learning style will affect the relationship between entrepreneurial network and learning effects (Rowley et al. 2000). Based on this and the preceding analysis, this article argues that trust-based informal networks can get a lot of reliable information which the implementation of exploitative learning needs. So the exploitative learning has a comparative advantage in the effect of informal network on growth performance. Adopting low-cost exploitative learning will be more conducive to the conversion of tacit knowledge. Informal entrepreneurial network affect growth performance through exploitative learning, while formal network can enable entrepreneurs to obtain heterogeneous information from multiple sources, which meet the demand of exploitative learning. So for formal network, explorative learning has a comparative advantage, which will be more efficient for enterprise to use and transform the knowledge contained in formal network through explorative learning.

Hypothesis 3a: Exploitative learning is more conducive for informal networks to generate positive impact on the growth of new enterprises.

Hypothesis 3b: Explorative learning is more conducive for formal networks to generate positive impact on the growth of new enterprises.

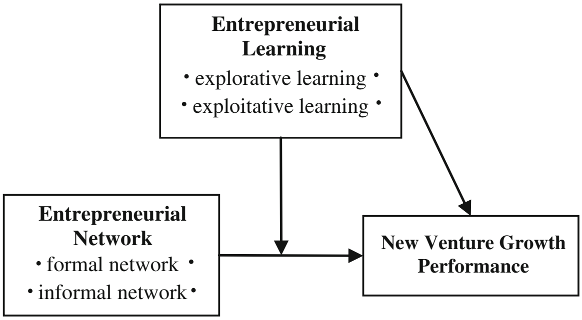

Fig. 179.1 Theoretical model

Table 179.1 Configuration of sample

Item	Category	Frequency	Percentage (%)
Industry	Agricultural byproducts processing industry	4	3.0
	Manufacturing	42	31.6
	Bio-medicine	4	3.0
	Construction industry and real-estate	8	6.0
	Transportation, storage and post	3	2.3
	Finance	8	6.0
	Wholesale and retail	20	15.0
	IT industry	24	18.0
	Services	6	4.6
	Else	14	10.5
Firm age	1–2 years	23	17.4
	3–4 years	29	21.8
	5–6 years	45	33.8
	7–8 years	36	27.0
Firm size	1–20	23	17.3
	21–50	27	20.3
	51–200	43	32.3
	201–500	19	14.3
	501–1000	9	6.8
	Above	12	9.0
Total		133	100

179.3 Research and Design

179.3.1 Data Collection and Sample Characteristics

Learned from McDougall, Robinson and Zahra, we defined enterprises established within eight years as new ventures. The data was collected by questionnaires. 130 effective questionnaires in total were obtained. The number of valid questionnaires is 5 times greater than the research variables, which meet the requirements of the effective research. From the sample enterprises, we can see that the age distribution of the sample companies is relatively uniform. Company size is mostly concentrated in less than 200 people. These samples involved in the manufacturing, bio-medicine, transportation, finance, IT industry and services. Overall, the distribution of the samples is extensive, and there exsits no concentration phenomenon, so the sample data are representative (Table 179.1).

179.3.2 Research Variable and Measurement

The variables of this study include entrepreneurial network, entrepreneurial learning and new venture growth. Entrepreneurial networks include formal networks and informal networks. According to Kiong & Yong, we use the degree of tightness between entrepreneurs or new ventures and their friends, relatives and colleagues to measure informal networks, and the degree of tightness between entrepreneurs or new ventures and government departments, industry associations to measure the usage of formal networks. The scale of entrepreneurial learning referenced the scale which designed by Atuahene-Gima and Jiang Chunyan. Using new ventures' degree of involvement on the current areas of market, product information research and accumulation to measure the exploitative learning, and the degree of familiar on the market of new and high-risk areas, product information, accumulation and involvement to measure explorative learning. Measurement of the growth performance of new venture referenced the research results of Ding Yuefeng and Geng Xin, using market share growth, "sales growth", "profit growth", "the growth of the number of employees "and "the increase of overall competitiveness" to measure. In addition, we take firm size and industry as control variables.

179.4 Results

179.4.1 Reliability and Validity

We use Kaiser–Meyer–Olkin and Bartlett Sphere Test to test questionnaires' reliability and validity. The results show that the KMO of all variables are all above 0.75, and the Bartlett sphere test result is significantly different from zero, which are fit for factor analysis. And using the principal component analysis method to analysis factor loadings, the results show that the questionnaire validity is good. Factor analysis of the entrepreneurial network has collected 71.2 % of the variation. According to its meaning; the two factors are named as the informal networks and formal networks. Similarly, Entrepreneurial learning extracted two factors defined as explorative learning and exploitative learning. The new venture growth extract a factor named as the growth performance (Table 179.2).

179.4.2 Data Analysis and Explanation

Comparing the mean score of the two kinds of entrepreneurial learning of sample enterprises, we divide the sample into two groups (explorative learning and exploitative learning), using a linear regression method to study the impact of different types of entrepreneurial network on new venture growth performance.

Table 179.2 The reliability and validity test

Variables	Index	Factor loading					α
Informal network	EN01	0.741	0.221				0.732
	EN02	0.877	0.223				
	EN03	0.668	0.358				
Formal network	EN04	0.154	0.766				0.905
	EN05	0.220	0.817				
	EN06	0.484	0.748				
	EN07	0.393	0.782				
	EN08	0.338	0.839				
Exploitative learning	EL01			0.927	0.142		0.870
	EL02			0.931	0.165		
	EL03			0.910	0.218		
Explorative learning	EL04			0.370	0.670		0.718
	EL05			0.007	0.915		
	EL06			0.177	0.741		
Growth performance	GP01					0.788	0.875
	GP02					0.877	
	GP03					0.851	
	GP04					0.796	
	GP05					0.782	

Table 179.3 The regression results [a]

Groups	Exploitative learning		Explorative learning		Both	
Model	M1	M2	M3	M4	M5	M6
Age	−0.018	−0.293*	−0.308**	−0.286*	−0.316**	−0.176
Size	−0.006	−0.039	0.032	0.098	0.063	0.121
Industry	0.062	−0.080	0.041	0.052	0.037	0.020
Formal network	0.308*		0.805***		0.512***	
Informal network		0.424**		0.401**	0.319**	
Exploitative learning						0.414***
Explorative learning						0.521***
F	5.13	10.76	11.47	10.54	15.27	11.61
Sig. of F	0.028	0.002	0.000	0.002	0.000	0.000

[a] Dependent variables: growth performance
* Correlation is significant at the 0.05 level
** Correlation is significant at the 0.01 level
*** Correlation is significant at the 0.001level

We can see that the two types of entrepreneurial networks (formal networks, informal networks) both have positive significant impact on new venture growth (Hypothesis1a, Hypothesis 1b are proven). So no matter emotional trust-based informal networks or formal network based on the interests of cooperation, maintaining extensive and close network relationships are conducive to the growth of new ventures. Form two sets of regression coefficients, the formal network had the greater the impact on new venture growth, we think that knowledge and information in formal network play a greater role in new venture growth. The two types of entrepreneurial learning also had a positive significant impact on new venture growth (Hypothesis2a, Hypothesis 2b are proven). However, the comparison of two sets shows that explorative learning has played a more significant role of new venture growth. Therefore, the behavior of a series of enterprise with characteristic of innovation can better and faster promote the new venture growth (Table 179.3).

From the comparison of the standardized regression coefficients, we find that the standardized regression coefficient of exploitative learning is greater than explorative learning. But the regression coefficients under the two learning styles have no significant difference in the statistical sense, the hypothesis 3a is not proven. On the contrary, the hypothesis 3b is proven. We think that explorative learning is more conducive for formal network to produce a more positive impact on the growth of new ventures.

Figure above shows that entrepreneurial learning has a more obvious effect on the regulatory impact that the network has on new ventures. That is to say, numerous heterogeneous information implied in the formal network require further innovation and transformation before it can be applicable internal knowledge of the business growth. Therefore, exploratory learning does better in promoting the achievement of performance (Fig. 179.2).

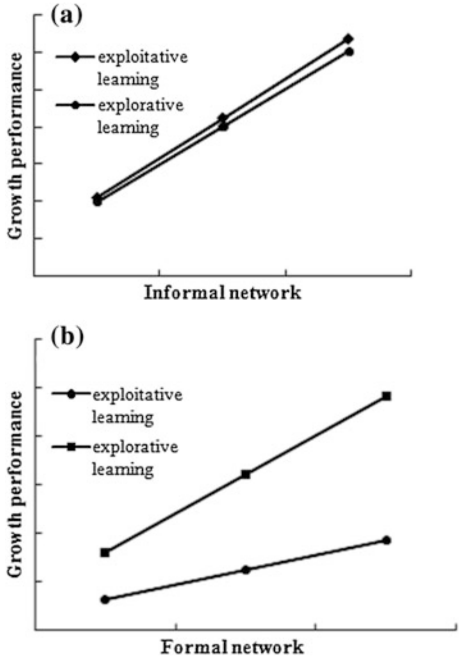

Fig. 179.2 The regulating action of entrepreneurial learning on **a** informal network, **b** formal network

179.5 Conclusions and Recommendations

Based on the theoretical analysis of how entrepreneurial networks and entrepreneurial learning affect the new venture growth, we have made an analysis on how the two types of entrepreneurial networks and two types entrepreneurial learning impact the new venture growth, and we also discussed the regulation of entrepreneurial learning. Empirical tests found that both emotion and trust-based informal networks and formal networks which based on the interest and cooperation have a positive impact on the growth of new enterprises, exploitative learning and explorative learning also have a positive impact. Explorative learning characterized by innovation is more conducive to the growth of new venture. The test results of regulation show that explorative learning is more conducive for formal network have a positive impact on growth performance of new venture, while comparative advantage of entrepreneurial learning is not obvious for informal network to have a impact on growth performance. The reason maybe that the two ways of entrepreneurial learning in informal entrepreneurial networks on growth performance has certain advantages, and the final result does not show that entrepreneurial learning has a comparative advantage.

Both of the new venture and its entrepreneurs should actively expand the scale of the network of individuals and organizations. At the same time, they should closely contact with the members of the network relationships, enhance the communication and trust between them and promote the flow of the knowledge.

Besides these, they should also enhance the understanding of the importance of the formal network and transform and use its knowledge and information through various means positively. In the utilization of the network, we can use the information in an informal network by exploitation learning. However, in the process of development and utilization of form networks, in the view of the complexity of the transformation from formal network to growth performance, this study supposes that we should take advantage of exploratory learning and supplemented by exploitation learning. Thus, on one hand, we can avoid the problem of high cost and diseconomy cost by completely implementing two kinds of entrepreneurial learning at the same time. On the other hand, through encouraging continuous entrepreneurial learning, we can alleviate the embarrassing position that new venture's growth speed become more and more slowly with the passage of time.

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Chapter 180
Research on Education System for Information Management and Information System Based on Three-Dimensional Model of Practice

Shi-hai Tian and Xiao-meng Zhang

Abstract With the rapid development of information technology, the requirements of society for IT talents are changing continuously, mainly reflected in the demand for innovative applications of talents. Compared with the original teaching system, information management and information system major should be reformed, to meet the needs of the society, and training the talents of professional field to adapt to social changes. This paper take Harbin University of Science and Technology as an example, through the establishment of three-dimensional practical teaching system, take training plan form theory teaching into education track which attention to both theoretical research and practical operation., so as to achieve the goal that transport composite applications talents of information major.

Keywords Information management and information system · Three-dimensional practical teaching system · Training innovative applications of talents

180.1 Introduction

With the rapid development of information technology and the acceleration of information process, enterprises put forward higher requirements for training professionals of information management and information system. Not only should the professional students have certain professional theoretical knowledge and basic skills, but also use technologies, such as development of market

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management tools, maintenance of market management tools, use market management tools, more skillfully. It is very necessary to reform the existing system, especially to strengthen the practice training (Zhu 2008; Qian and Ye 2009).

In the development planning of information management and information system major of Harbin University of Science and Technology, in order to realize talent cultivation conception which is "wide caliber, heavy practice, strong ability", theory teaching must be turned into education track which attention to both theoretical research and practical operation, so that it can stimulate students' subjective initiative of cognitive activities, and enhance students' effectiveness of practice activities such as knowledge migration, combine study with application, and etc., and guide students to cultivate innovation capability of scientific work and learning style, and even more promote the students' comprehensive and depth understanding of whole disciplinary system.

180.2 The Training Goal of Information Management and Information System

The Ministry of education has made clearly provision on the total direction and target of Information Management and Information System major setting, which is training senior specialized talents who with the modern management theory basics, computer science technology and application ability, and master the knowledge and ability of Information Systems' ideas and Information System analysis and design methods, and Information Management science, and etc., and also engaged in the kind of work which is analysis, design, implementation and evaluation of Information Management and Information System in the all levels of national administration departments, enterprises, financial institutions, scientific research units and other departments (The People's Republic of China Ministry of Higher Education 1998).

The cultivation target makes clearly that students in the major of the Information Management and Information System should have levels of knowledge, it The targeted training information students should possess the knowledge level, it reflects the characteristics of the professional teaching, and also clarify the professional field of employment. The construction of Information Management and Information System in our college aims at training pyramid professional talents of "Extensive", "Deep", "Honored", "Profound", training target as shown in Fig. 180.1.

180.3 The Analysis of Existing Teaching Content

Because of Information Management and Information System major is formed by the multiple disciplines, and construction time is very short, and the basis and the focus of the institutions is various, is different, and before the combination, it

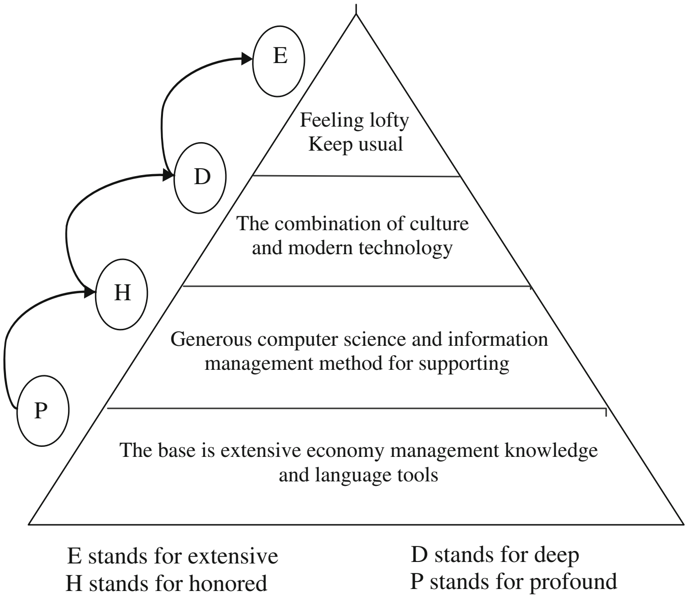

Fig. 180.1 Training target

belongs to different disciplines, thus, after the combination, it reflected to be either focus on a subject or the "platter" phenomenon of the various disciplines of knowledge. The most prominent manifestation is: the professional's coverage of discipline knowledge is broad but the integration is not enough, and the courses offered by the students during the school quite a lot but the content of the courses are not deep enough. So there is a phenomenon that talents who cultivated by "edge" discipline are meeting an awkward situation that they are squeezed by talent market. Information Management and Information System of Harbin University of Science and Technology in its establishment procedure of practical teaching system exists the following problems:

(1) *The theory of teaching content is excessive:* Theoretical courses in the curriculum are too much, in a specific course, the teaching content of the theory is excessive. Lake of necessary application content (for instance cases teaching or practical activities), so this is increase students' understanding of the knowledge, cut the link between the theory and practice application, put off the time to adapt to the actual work, pay no attention to effect of practical teaching on knowledge interconnect (Du et al. 2007).
(2) *Focus on imparting knowledge, lack of ability training:* In previous teaching, the teachers pay more attention to the imparting of knowledge, but at the same time, they ignore the students' cultivation of learning methods and self-learning ability, and neglect the cultivation of innovation ability too. So that made students had poor application capabilities from a wide range, which

include experimental operating capacity, communication skills, management capacity, creation ability and etc. There has some obstruct for inter-disciplinary talent who understands both economic management and information technology (Sun 2010).

(3) *The curriculum is short of integration:* The courses which are set in the curriculum system are relatively independent, the same conception in different courses is repeated a number of times or ignored in different classes, all these phenomena are caused by human (Liu et al. 2011). Therefore, we should break those man-made "barriers", between certain subjects and courses, which due to the limitation of knowledge, and study the course content from the higher vision, if we do like this, the teaching focus and level will be more outstanding, and the structure of the discipline knowledge will be more reasonable, and a number of integrated courses which contain new ideas and reasonable structure will be more prominent.

180.4 Practical Teaching System Design

180.4.1 Total Design

The Information Management and Information System major of our college offered courses on both Economics and Management and Computer Science and Technology. The purpose of this major is want the students know clearly about the relationship of all courses and the role it is play in the teaching, so that the students can integrate the theory, then apply the technology which they learned and improve their capabilities of information system development. It is necessary for students to have a large number of practical training systematically (Ni 2010). Only through the practice, knowledge can be turned into real, direct and specific knowledge; and only in this way, knowledge can be turned into wisdom, true and creative intrinsic motivation (Zhang 2002). In view of the different Professional direction, we must encourage and guide the students to do innovative experiment, and we present three-dimensional practical teaching system: Platform + professional training + subject contest (as shown in Fig. 180.2). On the basis of ability training, the curriculum is further training the actual application ability, and finally, on the basis of a certain development capabilities, training students' comprehensive ability and innovation ability through the academic competition, as a result, the students can lay a good foundation for the graduation design.

(1) *Platform experiment:* Computer course and other courses that need to be equipped with the experiments are arranged in the curriculum with experiments. Experimental group which must learn to use system development software and tools to development, manage or maintain one information

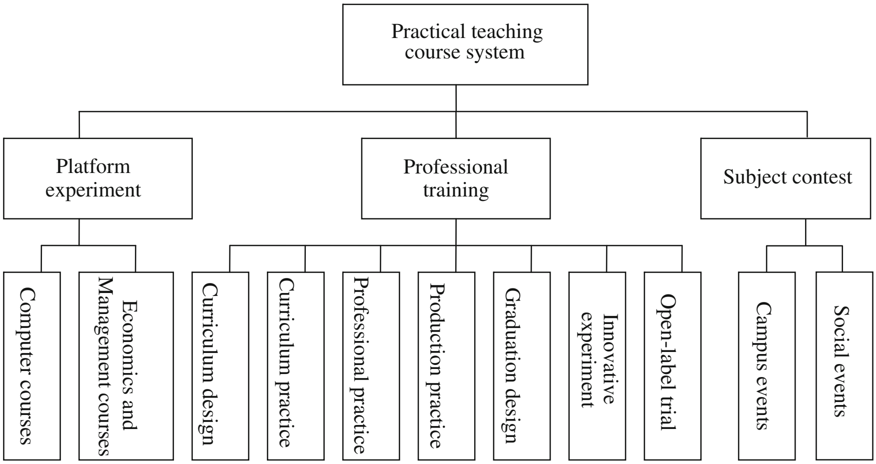

Fig. 180.2 Three-dimensional practical teaching system

system which allow students to apply the knowledge into actual operation and develop their innovation ability by use information technology.

(2) *Professional training:* On the basis of deep understanding about the theory, technology and method, it is important to train the students' practical application of innovative capacity. Now take the enterprise visiting practice, ERP management application software, E-commerce practice for example to introduce the Information Management and Information System major.

(3) *Subject contest:* As an effective complement to college training, we should organize the students to participate in various competitions activities which are related to the curriculum, these competitions activities include undergraduate innovative experiments, opening experiments, ERP sand table simulation contest, ERP software contest, e-commerce competition, international business management challenge, and etc.

The ultimate goal of practical teaching reform is to let students grasp and use all kinds of specialized knowledge and technology, and cultivate their ability about some activities like experiment, research and development of Information Management and Information System major, and have a comprehensive ability of using knowledge which learned in classes (He et al. 2010).

180.4.2 Specific Design

1. Teaching methods

The basic method of practical teaching system establishment is reform the traditional curriculum system and teaching method. After many years of practical teaching, we have already accumulated some experience in teaching. We are trying to reform the teaching method and teaching mode because of the interests of students about practical teaching.

(1) *Combine the theory explanation with discussion in the class:* We adopt this kind of teaching methods that students can interactive learning with each other like seminar, heuristic and cooperative teaching when we are solving difficult problems, which can make the students think independent and increase their learning interest and improve learning quality through holding group discussion.
(2) *Adopting case teaching method:* Through the case teaching, we are trying to turn the abstract theory into specific knowledge, so that the students can accumulate theoretical knowledge before practice through understanding and memory the theory, and they can get best results at last.
(3) *Homework:* We are trying to strengthen students' understanding of the knowledge, and train students' application ability by allowing students to do homework, so that students can master the technical and economic evaluation method well.
(4) *Make full use of modern teaching means:* We are trying to increase the information content of classroom teaching and improve the efficiency of classroom teaching through developing the electronic teaching plan and multimedia courseware.
(5) *Change teaching conception:* We are trying to turn the traditional teaching to the research studding, exploratory studding, and cooperative studding. We should pay attention to the interaction with students, and promote the quality of teaching by multiple ways.
(6) *The combination of theory teaching and social demands:* We are trying to develop some design task to let the students realize the core idea and principle about developing information management systems, and improving their ability of using computer hardware and software, and abilities of analyzing, designing, developing, managing and maintaining information system (Zhang and Li 2007).

2. Forms of curriculum organization

The two organization forms of practical teaching curriculum: independent experiment and the group experiment. According to different teaching contents, their organization form is different in the implementation stage.

The content of independent experiments is experimental experiments and operational experiments. We ask students to finish all the experiments independent. The time arrangement is: finish some experiments in class, finish the other experiments by themselves after class independently. Lab assignments are submitted online.

Group experiments' content is designing experiments and a small amount of operational experiments. All the students who participated in the designing experiments can develop their abilities in the group experiments because of involving more content. Each student who attends to the group experiments was asked to exist from the beginning to the end, we are trying to good results by discussion, comprehensive design experiment program, collecting data, making plan.

3. Assessment methods

Designing program, planning program reports' quality, effects of experiment is included in experimental assessment. In each experiment, the teachers should assess students' thinking ability and experimental. After finishing the experiment, the students must complete the lab report independent or in groups. Designing experiments which completed by the experimental group is reported in written form, the teachers based on it to complete the assessment scores.

The experiment was divided into the "preparation phase" and the "experimental stage". The students who could not finished in the "preparation phase" are not allowed to enter the "experimental stage", "preview" is reported in assessment, "material" refers to preparing the experimental materials (including data), "instrument" refers to preparing the equipment of the experiment, in the "attendance", the student who has absent would get zero in his or her "total score", "operation" refers to the experimental method is consistent with the experimental procedures, "report" is required by experimental requirements which include format and charts. The proportion of ratings of each stage is as follows: the preparation stage accounted for 20 %; the experimental stage accounted for 80 %; a total score of 100 points.

180.5 Conclusion

Practice teaching system put the mobilization, independence and creativity of students' learning initiation as the breakthrough point. It is important to emphasis the ability of thinking and analyzing problem and practical ability. In concrete measures, combine inside classroom with outside classroom, and inside school with outside school, guide students to participate in the teachers' scientific research project, lead the students to use what they have learned in class to analyze social economic problems, encourage the students to participate in various competitions. In recent years, we get success in a number of domestic discipline competitions.

The practice teaching system is the foundation of the entire profession, the practical teaching content and condition of the building is particularly important. The practice teaching position is laboratory, and it ensures the quality of practice teaching. The practice teaching system is a combination of teaching theory and teaching practice. The professional construction is three-dimensional teaching laboratory which scientific, reasonable, and required by teaching experiment. Improve the experimental environment and conditions greatly to provide experimental environment for improving the students' ability of system analysis and system design, and make the students practical ability be greatly improved.

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Chapter 181
Research on the Mechanism and Conditions of the System Stability of the Banking Under the Competition Effect

Jin-feng She and Mei-xia Li

Abstract Along with the economic globalization and financial liberalization, bank competition has impacted on the banking stability profoundly. But the effect of bank competition on individual bank stability and the whole banking system stability is different. Based on the related articles at home and abroad and the analysis of the competition and stability of the banking in China, this paper thought that it is uncertain whether bank competition is good for the development of the bank individual stability. However it is beneficial to the system stability of the banking. This paper analyzed the mechanism of the stability of the system and conditions under the effect of banking competition by use of the system self-organization theory and the survival of the fittest theory.

Keywords Bank competition · Stability of the banking system · Stability mechanism · Stability conditions

181.1 Introduction

Financial is the core of the modern economy, bank was regarded as the principal part of finical activities. Its steady development has great impact on harmonious and sustainable development of social economic system. With the economic globalization and financial liberalization, the banks face more and more competition, which produces far-reaching effect on banking stability. What kind of impact does competition in the banking sector have on banking stability? And how

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it affects banking stability? These issues become the hotspot of theoretical research and practical research at home and abroad in recent years, but the conclusions are not consistent.

This paper attempts to summarize the situations of competitive effects on the stability of the banking system by studying the related literature and analyzing the competition and stability of the banking industry in China. Furthermore, the system self-organization theory and the survival of the fittest theory are used to analyze the mechanism and conditions of the banking system stability under the effect of banking competition.

181.2 Literature Reviews

There are two different views about the effect of bank competition on bank stability. Some early scholars held the view that the banking competition was not benefit to the stability of the banking industry. Such as, Keeley (1990); Alien and Gale (2000) considered that fiercer competition among banks would erode the incumbent monopoly rent and reduce the franchise value. As banks franchise values erode, this may create incentives to gamble and may lead to a shift towards riskier activities. Shaffer (1998) found a phenomenon in the United States that the borrower's overall quality was declining in the financial market with the increasing number of the banks. The reason is that, when there is fiercer competition among banks, it would affect selecting criterion to bank lenders. If the applicants are refused by one or more banks, they can continue to apply for other banks. If the competition between banks is intense, and there is no cost or low cost for the lender loan application frequently, the low quality enterprises to obtain loans will be improved. Hellman et al. (2000) found that financial liberalization in United States and Japan reduced the enter doorsill for banking industry, relaxed the control of interest rate, and increased market competition of deposit through the establishment of deposit dynamic competition models. Therefore, banks tried to expand sources of funding by raising deposit rates. Raising the deposit interest rate means an increase in the cost of funds. It would erode the banks' profits, reduce the franchise value, and encourage banks to take more risk. Cordella and Yeyati (2002) studied the bank competition effect on supervisory, they considered that banking competition reduced the investment for bank supervise. In the further proof, Repullo (2003) thought the key factor, which make the competition encourage banks to take excessive risk, is that the risk revenue was mainly to bank shareholders, while the bear of loss was mainly shouldered by government or depositors.

However there are more and more researchers get the conclusion that banking competition is conducive to the stability of the banking through empirical research in recent years. In this view, they thought that a high concentration banks would get political asylum, accept the high lending rates from customers, and lead to more adverse selection and moral hazard. Such as, Boyd (2004) considered that the probability of bank failure was positively correlated with the degree of concentration, the loan-to-assets ratio had a significant negative correlation with the degree of concentration, and there was a significant positive correlation between bank profits and the degree of concentration and a trade-off correlation between bank competition and financial stability. Cihák and Schaeck (2012) concluded that the highly competitive banking system was not prone to banking crises by studying on the relationship between bank competition and financial stability form the 38 countries from 1980 to 2003, including Japan, China, the United States, Germany, and so on. Guo Jun analyzed the relationship between banking competition and stability from the functional point, and concluded that the instability of the banking system was caused by the bank's functional conflict, while the competition within the banking can effectively cut the bank's functions conflict, improve the matching function and effectively enhance the stability of banking system. Zou Peng-fei (Zou and Yang 2011), by studying the impact of bank competition on bank stability from an empirical point of view, obtained the results that as the credit market competition degree rise, the bank's bad loan rate reduced ceaselessly, the capital adequacy improved continuously, and the overall stability enhanced constantly.

There are two reasons why the impact of competition on bank stability has different conclusions in the existing literature. First of all, the different literature has different research object, some literature is based on the bank individuals, and the others is based on the whole banking industry. Second, the financial environment of different research object is not the same, different countries in different period has different financial environment, in which impact of bank competition on stability is different. Therefore, it is difficult to obtain a unified conclusion.

181.3 Analysis to Competition and Stability of China's Commercial Banking

With the deepening of China's financial reform, the market structure of China's banking industry had great changes. China had formed competition situation of state-owned commercial banks, joint-stock banks, city commercial banks and other banks co-exist, and market concentration is reduced year by year (showed in Table 181.1). However, the data in the table shows that total assets of four major state-owned commercial banks is still dominant, China's banking industry is still in the stage of monopolistic competition and has not yet reached the moderate competition.

Along with financial market competition degree in the banking industry increasing in China, how does the banking stability change? We try to analyze it by the means of correlation analysis between banking competition and stability. Generally, we use industry concentration ratio index (CRn) and Herfindahl–Hirschman Index (HHI) to reflect the competition degree. From reflection of

Table 181.1 The assets SCAE and market structure of China's banking from 2001 to 2008

Years	Total banking assets (billion yuan)	The share of four major state-owned commercial banks in total assets (%)	The share of shareholding commercial banks in total assets (%)	The share of city commercial banks in total assets (%)	The share of other financial institutions in total assets (%)
2001	158418.1	77.1	–	–	–
2002	236643.8	75.0	–	–	–
2003	276583.8	54.9	13.8	5.3	25.9
2004	315989.8	53.6	14.9	5.4	26.2
2005	374696.9	52.4	15.5	5.4	26.6
2006	439499.7	51.3	16.2	5.9	26.6
2007	525982.5	49.2	13.8	6.4	26.6
2008	623912.9	46.7	14.1	6.6	28.2

Data sources Chibna CBRC statistics from 2001 to 2008

Table 181.2 The competition of China's banking from 2001 to 2008

Years	Industry concentration ratio index (CRn), n = 4	Herfindahl–Hirschman Index (HHI)
2001	0.771	–
2002	0.750	–
2003	0.549	0.390
2004	0.536	0.381
2005	0.524	0.372
2006	0.513	0.364
2007	0.492	0.336
2008	0.467	0.322

table 181.2, these two indexes gradually decreased since 2001, witch indicates that the competition of China commercial banks enhances gradually.

To keep the stability of the banking, we can select the index of bank non-performing loan rate to represent the banking stability. The rate of non-performing loan is an important indicator to reflect the banking soundness, which can reflect the stability of the banking sector in a certain extent. The smaller the index value is, the better the stability of the banking is.

This paper analyzed the correlation between the concentration ratio index of banking industry and bank non-performing loan rate form 2001 to 2008, the correlation coefficient between them is 0.9114 (Table 181.3), which shows that there is a strong positive correlation between degree of banking competition and stability. This analysis also shows that, when not reach the moderate competition, banking stability will increase along with the degree of the industry competition enhanced.

From the existing literature and the situation of banking competition and stability in China, the effect of competition on individual bank stability and banking system stability is different. On the terms of the individual bank, competition may

Table 181.3 The correlation between the competition of China's banking and non-performing loan ratio

Years	Industry concentration ratio index (CRn), n = 4	Non-performing loan rate (%)	Correlation coefficient
2001	0.771	25.35	0.9114
2002	0.750	25.00	
2003	0.549	17.8	
2004	0.536	12.8	
2005	0.524	8.6	
2006	0.513	7.02	
2007	0.492	6.17	
2008	0.467	2.45	

improve its stability, or reduce it, or even collapse. But as a whole of the banking industry, the competition orderly will enhance the system stability of the banking under financial resource constraints, and whether the competition is insufficient or excessive will bring adverse effect.

181.4 System Stability Mechanism of Banking Under the Competition

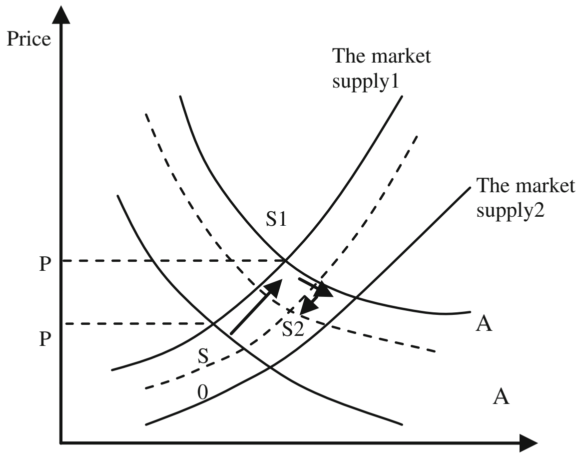
Financial resources are a kind of scarce social resources, which determined the fierce market competition among the commercial bank subsystems and internal banks. This competition promotes system stability of the banking mainly from two aspects.

On one hand, the banking system is a self-organizing system with dissipative structure. From the perspective of self organization system evolution, the competition between banks not only makes banking system far from equilibrium state, but also promotes the system to the ordered structure evolution. Under the condition of market economy, banks face a different environment and resource condition. The responses of banks to market competition are also different. So the competition forms a kind of environmental forces which make all banks away from the equilibrium, into a dynamic non- equilibrium (Chen and Fang 2008). Specifically, competition can promote banks to carry out a variety ways of financial innovation, which not only makes the bank have the enough development at multiple levels, but also make the bank management efficiency, improve economic efficiency and promote their competition ability. At the same time, competition leads to the emergence of new ideas, new strategy and new combination in bank system, which promotes the bank's overall efficiency. In addition, competition can makes bank effort degree information open to the public, which could achieve more effective supervision and incentive to bank operator. Because of the competition makes banks facing the decisions between life and death, the bank must constantly improve its management mechanism and operational efficiency to survive.

On the other hand, the main feature of the competition is the survival of the fittest. When facing on the external environment and condition, the different type banks in banking system have different adaptation and response, and the acquisition of material, energy and information quality are also different. All these cause the competition and survival of the fittest. Survival of the fittest mechanism of commercial banks have screening function, which can retain good banks of high efficiency and eliminate the poor efficiency banks, so as to enhance the overall quality and stability of the commercial banking system (Nuojin 2007). Survival of the fittest mechanism of competition is achieved by price mechanism. Competition promotes price changes in financial market, which have different effects on different banks. Under the environment of market competition, the bank whose marginal cost is higher than the market price will incur losses. And if the bank's loss endangers bank capital, it will withdraw from the market. In contrast, the bank whose marginal cost is less than the market price will continue to live.

In Fig. 181.1, S0 stands for the initial market equilibrium, P0 and Q0 stand for the corresponding prices and the number of banking institutions respectively. With the development of economy, the financial service demand is increased. Assuming that the demand increase Q1, the prices will rise to P1 if the bank quantity is same. On the one hand, the prices increases profit space of the bank, which makes bank supply quantity increase and bank competition increase. And on the other hand, it can inhibit the demand for financial services, and decline the demand. Falling demand and survival of the fittest mechanism of competition make the equilibrium point at S2. And as this process continues, the banking system will get to automatic balance.

Fig. 181.1 The dynamic stabilization process of banking system under competition



181.5 Condition of the Banking System Stability Under the Competition

To achieve dynamic system stability by self organization, bank must meet the following conditions: All bank institutions should adjust their behavior independently according to the changes in the financial environment, the diversity of bank institutions which can realize full competition and the smooth entry and exit channel of banks for the survival of the fittest.

(1) Independence of bank institutions

An independent bank institution has four basic characteristics. (1) It provides financial products and services as the main source of its income, and its goal is to maximize the benefits. (2) It must have the property right, by which it has the ability to take full responsibility and cost. (3) It has the independent decision-making right. Otherwise, it would produce asymmetry of duty and right. (4) It has enough awareness of risk.

(2) The diversity of bank institutions

Similar to the stability of the ecological system, the system stability of the banking also relies on the diversity of bank institutions and the complexity of financial food-chain relations. Banking diversity mainly embodies the following like the diversity of financial institutions, the diversity of financial property right, the structural diversity, financial organization diversity, species diversity, and financial business and service diversity. In the long-term evolution process, different bank institutions are different in the organization structure and organization function, which forms the food chain of financial organizations by complement each other and mutually dependent relationship. The more complex the food chain relation is, the more abundant nonlinear interaction in system is and the easier to restore stability under internal and external interference. Conversely, if banking institutions are the same in the strategy, business, structure, and asset concentration, the relationship within banking system is very simple, and the system will hide the certain systemic risk. When it receives interference factors, it is difficult for banking system to restore stability by the fluctuation among various components of the system.

(3) The smooth entry and exit channel of bank institutions

In order to make the competitive mechanism of survival of the fittest smoothly in the banking system, it needs to have appropriate entry and exit channel for banks. Entry means that the banking institutions added branches, opening new financial business, the innovation of financial instruments and financial transactions of property rights (such as merger, reorganization, transfer). Bank exit refers to the alteration or loss of the financial institution legal person status by the way of merger, division, dissolution, closure, and bankruptcy (Wang 2007). Banking entry and exit largely determined the competition degree in banking sector and its quantity. New life is the condition of ecosystem sustainability. Similarly, the bank entry is also the conditions of sustainable banking-system and only with effective access can make good financial institutions to achieve objectives of expanding the market and develop new markets or new areas of business. At the same time, bank entry is condition of competition too. No free entry, no full competition, and no full competition, no effective financial function. All that lives must die, which is the requirement of ecological balance, and it is also requirements of maintain financial stability. For those failing bank institutions, they would eventually threaten the interests of the public and depositors, so they should withdraw from the market. The International Monetary Fund's research also showed that it was vital to run banks exit on the stability of the banking system and competition.

181.6 Conclusion

Competition is an inevitable product of the market economy. Competition among banks is the driving force for the banking development and the necessary condition to achieve the system stability in the increasingly globalized financial environment. In the competition, banking system realizes the dynamic balance and stability of the system through its self-organization and mechanism of survival of the fittest. But, to achieve dynamic system stability by self organization, bank must meet the following conditions: All bank institutions can adjust their behavior independently according to changes in the financial environment, the diversity of bank institutions which can realize full competition and the smooth entry and exit channel of banks for the survival of the fittest. Therefore, in order to promote the stable development of the banking sector, it is important to reform the financial system and create a financial environment and conditions of orderly competition.

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Chapter 182
Education Image Retrieval Method Using Moment Invariants

Jian-guo Zhang and Wen-bo Wang

Abstract Shape-based image retrieval is an important part of image retrieval. According to the shape of moment invariant features of image, a new method for shape based image retrieval is presented. Firstly the edges in the original image using Canny operator are detected, the moment invariants of the edge map are calculated, and the moment invariants as the shape features are automatically indexed. Then, the similarity metrics to accelerate the match are redefined. Finally, the aspect ratio was defined to improve the retrieval precision. Experimental results show that the new method can remove some irrelevant information related to shape in the original image and weaken its influence on the retrieval results to some extent. This new method is simple and efficient and it is of some practical significance. This image retrieval system for education has made a good search result.

Keywords Image retrieval · Shape · Moment invariants · Education technology

182.1 Introduction

The shape of the traditional characterization methods include: Fourier descriptor, differential chain code, hough transform, moment invariants, deformation models, such as quadratic curve and the axis transformation (Flichner et al. 1995; Castleman 1998; Hu 1962). Hu put forward the invariant moment Shape Features

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Representation (Belkasim et al. 1991), which has been widely used on shape-based image retrieval because of displacement, rotation and scaling invariant good nature (Mostafa and Psatis 1984; Yao and Zhang 2000). The general practice is a direct calculation of invariants moment by original image, or by binary edge image (Belkasim et al. 1991). However, the former calculation of volume, it is generally against the edge of the image to calculate the moment invariants (Huang and Huang 1998; Wu and Pan 1998).

In this paper, shape-based image retrieval method first use Canny operator of the image edge detection, getting the formation of the edge amplitude map images, and then mapping the image on the edge of the calculation of moment invariants as a visual feature vector. We re-define the weighted similarity measure to match the final output of the results ranked by decreasing similarity image sequence. This method simply maps to the edge of the calculation of moment invariants, as opposed to a direct calculation of the original image, reducing the computational. Experimental results show that this method is simple, effective and quick, which has a good compromise both speed and accuracy. The proposed method has a good practical significance in image retrieval of education.

182.2 Shape-Based Image Retrieval

Shape-based retrieval, the key is to find this image to describe the object shape and form a visual feature vector in order to complete the automatic indexing image database. Although the original image can be calculated to represent the visual features of moment invariants, but the calculation is too large. If we can calculate the invariant moments of edge map image, duing to give up the same gray-level information, while counting only a certain gray-scale pixel-point differential, which reduces the computational. At the same time the edge map image contains the edges of the main target of the information, and give up some of the color information independent of shape, thus the calculated invariant moments are more representative of the shape of the image. We use Canny edge detection image edge because the operator can detect the edge of delicate and accurate.

Figure 182.1 shows, Canny operator to detect the image edges under different thresholds. As can be seen, different thresholds for edge detection have a greater influence, so, the threshold value is more important the choice of edge detection. We direct calculation of seven invariant moments as the shape feature vector on the edge of map images by Canny operator resulting. Calculation procedure is as follows (Chen et al. 1995; Johnstone and Wilverman 1997; Flandrin et al. 2004; Teixeira et al. 2008):

First, scanning the entire image and using the Canny operator to get the edge map $edge(i,j)$, then calculating the $(p+q)$ order moment:

Fig. 182.1 The edge-detection results for different method. **a** original image, **b** sobel operator, **c** prewitt operator, **d** canny operator

$$m_{pq} = \sum_{i=0}^{M} \sum_{j=0}^{N} i^p \times j^q \times edge(i,j),$$

Computing center of gravity coordinates:

$$\bar{i} = \frac{m_{10}}{m_{00}}, \bar{j} = \frac{m_{01}}{m_{00}}$$

Computing the $(p+q)$order center Moments:

$$\mu_{pq} = \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} (i-\bar{i})^p \times (j-\bar{j})^q \times edge(i,j)$$

Regulating the $(p+q)$order center Moments:

$$\eta_{pq} = \frac{\mu_{pq}}{\mu_{00}^2}, s = 1 + \frac{p+q}{2}$$

Computing the seven invariant moment :

$$\begin{aligned}
\phi_1 &= \eta_{20} + \eta_{02} \\
\phi_2 &= (\eta_{20} - \eta_{02})^2 + 4 \times \eta_{11}^2 \\
\phi_3 &= (\eta_{30} - 3\eta_{12})^2 + (3\eta_{12} - \eta_{03})^2 \\
\phi_4 &= (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2 \\
\phi_5 &= (\eta_{30} - 3\eta_{12})(\eta_{30} + 3\eta_{12})[(\eta_{30} + \eta_{12})^2 \\
&\quad - 3(\eta_{21} + \eta_{03})^2] + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03}) \\
&\quad \left[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2\right] \\
\phi_6 &= (\eta_{20} - \eta_{02})\left[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2\right] \\
&\quad + 4\eta_{11}(\eta_{30} + \eta_{21})(\eta_{21} + \eta_{03}) \\
\phi_7 &= (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 \\
&\quad - 3(\eta_{21} + \eta_{03})^2] - (\eta_{30} - 3\eta_{12})(\eta_{21} + \eta_{03}) \\
&\quad \left[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2\right]
\end{aligned}$$

This seven invariant moments with the displacement, rotation and scaling invariant features of a good, and we use it to represent the shape characteristics of the edge map image (Kopsinis and Mclaughli 2009; Wu and Norden 2004; Lei et al. 2009).

The establishment of the image database, an image in advance of each operation and the constant Canny Moment, will be the same moments as the shape of visual features into the database to prepare query matching. The query process shown in Fig. 182.2, The *S* in Fig. 182.2 represents the Similarity.

182.3 Experimental Analysis

In order to validate the proposed shape-based image retrieval method is effective, we have made comparative experiments. First, we select about 200 figures including animals, landscapes, flowers, airplanes and other full-color images,

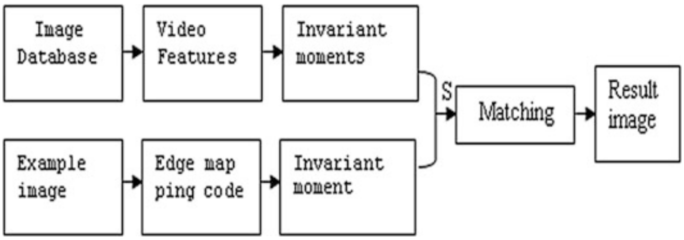

Fig. 182.2 The flow chart of image retrieval

which are child objects when the plug-in required knowledge. We use these images to composite a image database, and the role of operator of Canny edge maps computed seven invariant moments as the shape feature vectors put into the corresponding database fields. When the input query image, the first use Canny operator to the image edge detection, and then the output edge maps calculated seven invariant moments, and then this group of images in the same moment and libraries to match the corresponding moment invariant. Matching criteria based on a certain similarity or distance measure, we do not use the traditional Euclidean distance measure, but re-define the similarity measure according to experiment:

$$S = 1 - \sum_{i=1}^{7} W_i \left| \frac{\phi_i - \phi_i^e}{\max(\phi_i, \phi_i^e)} \right|$$

where, ϕ_i^e represent the *ith* invariant moment of the query image corresponding to the output of Canny operator map. W_i is the weight of the *ith* invariant moment. In this paper, we select the W_i as following: 0.25, 0.25, 0.15, 0.15, 0.1, 0.05, 0.05. Because we found the first four invariant moments contribute to the search results more through experiments, we get these weights which are conducive to the effective image retrieval. Figures 182.3, 182.4, 182.5 are the comparison experimental results.

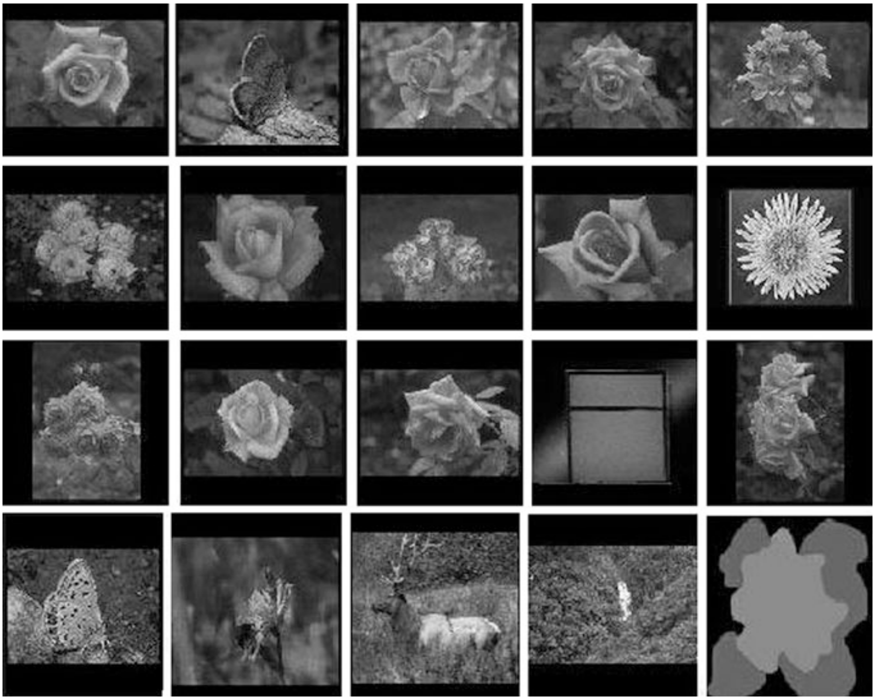

Fig. 182.3 The retrieval results according to moment-invariant of original images

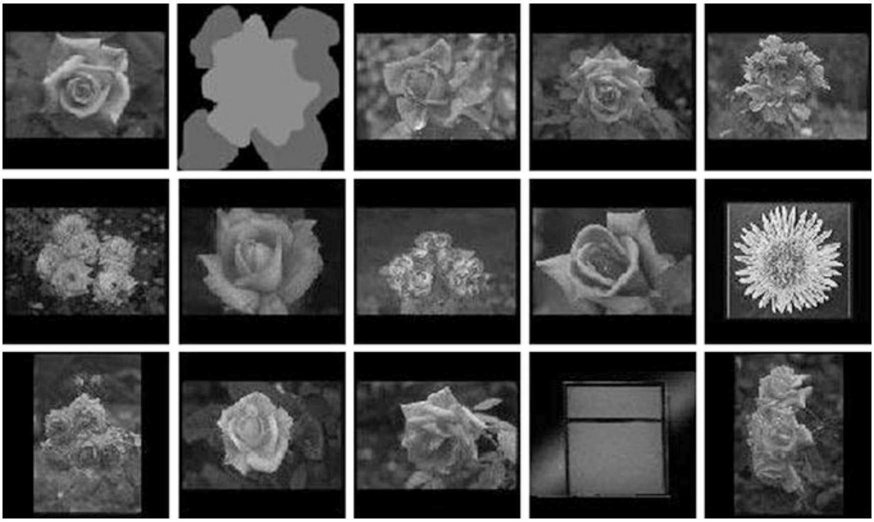

Fig. 182.4 The retrieval results according to moment-invariant of edge-map using Canny

Fig. 182.5 The retrieval results via aspect ratio based on Fig. 182.4

The upper-left corner image in block of images is the query.

Figure 182.3 shows the search images by directly calculating original image invariant moments as the shape characteristics, which arrange by descending similarity. As in the calculation of moment invariants and failed to do any image processing, moment invariants characterized inevitably include irrelevant information by the shape of the area of information, search results have a certain amount of bias. Figure 182.4 shows the query results according to the invariant moments of edge images with Canny operator, arranged by descending similarity.

Retrieval performance has a marked increase than Fig. 182.3 and excluding some irrelevant images such as the flower in Fig. 182.3. However, due to the rotation invariance of moment invariants, so that search results appear in the shape of the rotated 90° after a similar image. In fact, we do not want to judge it to be similar, such as the sitting cat in Fig. 182.4. So we added a visual feature vector element, namely, the aspect ratio, which is defined as the vertical and horizontal coordinates of the commercial center of gravity.

Among retrieval image, when an image consistent with similarity determination, the re-examination of its aspect ratio, only the query image and to be top of the image's aspect ratio is greater than or equal 1 or both at the same time is less than 1, we think that the two images is similar. Figure 182.5 shows the results of image retrieval after taking into account the aspect ratio. Query example image aspect ratio greater than 1, therefore, although the similarity measure, but in line with the aspect ratio is less than one images are removed.

182.4 Conclusion

This paper presents a new shape-based image retrieval method, which enables automatic indexing Shape Features. Using Canny edge detection operator to get the edge maps, and then calculated moment invariant features representing of the shape by edge image. The proposed method not only reduced the amount of some operations, but also reduced the shape information not related to the adverse effects of search results. The experimental results show that this method is simple and effective. We query the education images by this method and obtain very good image retrieval results. But if we want to achieve a real sense of the application, the large-scale educational image resource library must be build.

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Chapter 183
Research on Emergency Warning System for Natural Disasters Based on Multi-Sensor Information Fusion

Jiang Shen, Tong-zheng Zeng, Tao Li and Hong Zhao

Abstract Accordance with these problems of the frequent natural disasters and the serious losses caused by natural disasters, the paper constructs a natural disaster emergency warning model and decision-making support system based on the research of multi-sensor technology and information fusion technology, and the functions of modules and system structures are also analyzed and studied. The research of this paper provides strong support on technique and system for the natural disaster decision-making emergency and warning management.

Keywords Multi-sensor · Information fusion · Natural disasters · Early warning

183.1 Introduction

In recent years, the frequently occurring of natural disasters highlights the environment vulnerability, resulting in a lot of property losses and casualties, the emergency management has been concerned by many researchers and policy makers. The devastating 9.0-magnitude earthquake in Japan in March 2011 leads to secondary disasters such as tsunamis, nuclear power plant leaks, causing serious casualties and economic losses; in 2010, Zhouqu, Gansu suffered a heavy rainfall which caused flash flooding and debris flow; in 2008, China suffered snow disaster and Wenchuan earthquake which demonstrated the inadequacies of integrated emergency response system for natural disaster in China. Attentions should be given to the natural disaster detection and alarm systems after these events.

With the application of multi-sensor information fusion technology of the emergency warning system for natural disasters, system information can be

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mastered more comprehensively and accurately, natural disasters can be monitored and pre-warned timely and accurately, the overall efficiency and effectiveness of existing emergency response system can be improved, and then the system is to bring greater social and economic benefits and better capabilities of the information sharing. This study can also promote the process of emergency management research in China, improve the level of natural disaster management and emergency response capabilities and provide a scientific basis and technical support of establishing the daily countermeasures and contingency plans for the authorities, making mitigation planning, deploying disaster prevention and relief work and making city development planning.

183.2 Research Status at Home and Abroad and Technological Trends

183.2.1 Natural Disaster Research

Natural disasters are the event that the variability of natural factors exceeds the bear or adaptability of human society, thus affecting human life, property and the living security. Essentially, natural disasters are the results that the earth's natural environment alters role in human society, including both the role of natural factors and the role of human society, especially the role of human society to withstand or adapt to the natural environment changes, namely, natural disasters have natural and social attributes (UNDP 2004). Early researchers mainly associated natural disasters with hazard factors, they started natural disasters research with the growth characteristics and the formation mechanism of natural disasters such as typhoons, storm surges, heavy rain and floods and so on (Blaikie et al. 1994). In accordance with the types of natural disasters mentioned by National Comprehensive Disaster Reduction "Eleventh Five-Year Plan", natural disasters in China can be divided into 13 kinds: floods, droughts, typhoons, hail, lightning, heat waves, dust storms, earthquakes, geological disasters, storm surges, red tides, forest and grassland fires, and plant diseases and insect pests.

183.2.2 The Application of Information Fusion Technology

Multi-source heterogeneous information's multi-dimension, networking, dynamic characteristics requires information fusion technology to do multielement normalized fusion. Information fusion mainly includes two categories: fusion based on epistemology and fusion based on information theory, mathematical tools used in this field include probability theory, reasoning network, fuzzy theory and neural networks.

In terms of seamless integration of multi-information and data association, (Casasent and Yee 1993), put forward Probabilistic Data Association (PDA), (Bloon and Bar-Shalom 2001), proposed Neural Network Data Association (NNDA), (Bloon and Bar-Shalom 2001), constructed interacting multi-model associated filter, (Bozdag et al. 2003), put forward Joint Probabilistic Data Association (JPDA). NNDA, PDA and JPDA achieve the analysis of targets, sparse targets, high-density environment. In terms of multi-sensor information fusion theory, Waltz and Linas made comprehensive discussion on research, framework and application of the multi-sensor information fusion, Hall et al. made research on mathematical techniques in the multi-sensor data fusion, (Bar-Shalom and Formann 2003) proposed new ideas and methods of multi-sensor data fusion in target tracking field. In the 1980s, Chinese scholars began to apply multi-sensor information fusion technology on national defense, military and other fields, after 1990s, multi-sensor information fusion technology began to be used in robotics and industrial process monitoring system. Information fusion is studied less on the control problems in the field of complex systems, in addition to the reason for the complexity of the multi-element and multi-dimensional information, the integrated issues on information fusion, learning mechanism as well as historical data mining are also very complex.

183.3 Information Fusion Technique

Multi-sensor information fusion technology is a key technology of natural disasters monitoring and early warning in the decision support system, it joins all levels of various types of sensors located at each monitoring point into an effective network to achieve interoperability and comprehensive integration of information, of data acquisition and real-time monitoring tasks, the completion of each monitoring point. The role of multi-sensor information fusion system is the integration of multi-source information obtained by the various sensors to obtain more information than a single intelligence source and a better quality of information and information credibility, and greatly improve system access to information, the efficiency of the transfer, collection, processing, distribution and information applications (Chen and Huang 2001).

The study selects applicable integration structure to complete the information fusion. Information fusion system architecture can be divided into three categories, namely, data level fusion, feature level fusion and decision level fusion (Fabre et al. 2001).

Data level. It includes a lot of raw data collected by the multi-sensor system and the necessary signal pre-processing and analysis processes, such as signal noise removal, filtering, cross-correlation analysis, spectral analysis and so on.

Feature level. It makes effective decision to data fusion results, it generally corresponds to the diagnostic methods of the natural disasters.

Decision level. For the initial diagnosis of natural disasters, it supports decision-making to variety of countermeasures responding to disasters using decision fusion algorithms.

On the functional characteristics, this three-layer structure can respectively meet the requests of monitoring alarm, disaster diagnosis and disaster countermeasures in the natural disaster decision support systems.

Combining different sources of information or data collected by sensors in accordance with established rules can obtain more comprehensive and reliable awareness and understanding of the exact state of the object. The proposed rule methods include Classic reasoning method, Bayesian, Dempster-Shafer evidence theory, cluster analysis, expert system reasoning method and so on.

183.4 Natural Disaster Emergency Warning System Model Based on Multi-sensor Information Fusion

183.4.1 Information Fusion Model and Method Based on Multi-sensor

Because of information heterogeneity, uncertainty, multi-dimensional features of the complex system, we need to study the key integration and implementation issues such as multi-sensor technology, information fusion, adaptive control and so on; in decision-making and reasoning core technology, we need to study a variety of fusion strategies such as Case-Based Reasoning (CBR), Rule-Based Reasoning (RBR), realizing performance complement between CBR and RBR. The line of research preliminarily considered is realizing information collection, comparison and analysis by multi-sensor perception and integration, normalizing multi-parameter, and then on the basis of certain optimization criteria and the integration algorithm, realizing decision analysis and collaborative optimization using of CBR/RBR integration decision reasoning model by the multi-layer fusion.

183.4.2 Natural Disaster Emergency Warning Model Based on Multi-sensor Information Fusion

To obtain information to support the final decision-making and control the disaster timely and accurately, natural disasters information is detected by multi-sensor in this model, then pretreated by filtering and normalization processing, and finally processed by multilayer fusion in the multi-layer information fusion center (Yong et al. 2007) (Fig. 183.1).

Level 1: Information acquisition and preprocessing.

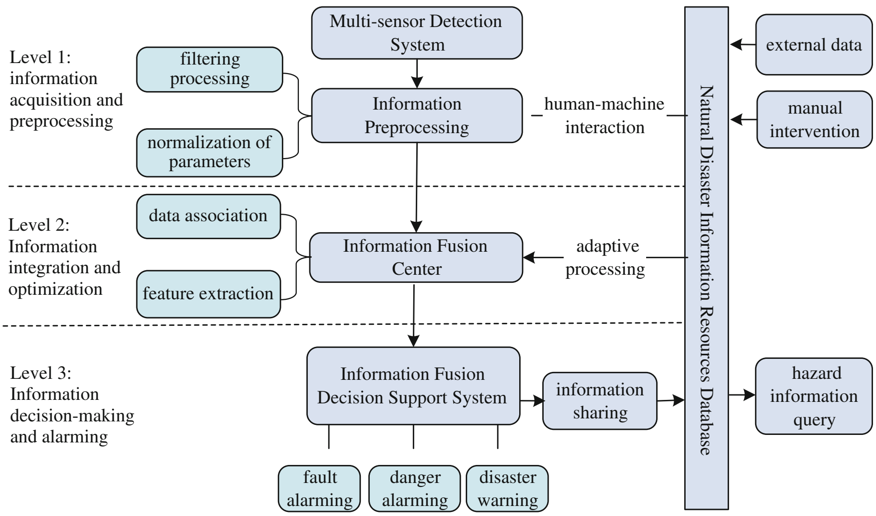

Fig. 183.1 Natural disaster emergency warning model based on multi-sensor information fusion

The data, information and knowledge detected by multi-sensor form a multi-layer, multi-dimensional, heterogeneous and complex information space. Noise and interference signals in the complex information should be reduced before multi-sensors information processing. The pretreatment methods include filtering (Geromel 1999) and normalization. The multi-sensor information is filtrated by building a filter model, the uncertainty fire information data parameters and sub-space features are normalized, so that multivariate information can be uniformly recognized and processed.

Level 2: Information integration and optimization

Though multiple natural disaster risk information has gone through the first level pretreatment, the essence of multiple heterogeneous information does not change. In order to achieve the fusion of these decision making knowledge which is uncertain, uncontrollable and heterogeneous in the data structure space, information fusion technology should be applied to build a multi-sensor information fusion model. Multi-sensor information fusion and optimization is done in the fusion processing center. In this center, multi-source information is processed in multiple levels according to certain rules and fusion algorithms. On the one hand, the information with the same purpose is connected (Jia et al. 2006), on the other hand, with the feature extraction of the associated data, a feature vector is obtained, and all feature vectors are merged so that we gain a target state or characteristics of target which are higher level than feature vectors. The results of the information fusion provide the basis and data support for natural disaster warning decision-making.

Level 3: Information decision-making and alarming

After multi-layer optimization of disaster information, the catastrophability still needs to be monitored by a decision support system to control disaster information, this level defines threshold of disaster information using multiple attribute decision making and multiple space scale analysis method, and then processes the information in the natural disaster warning system. This model puts the information processed as input factors of natural disaster warning decision system to definite threshold value, and gets system fault alarms, danger level forecast, and disaster alarming and response plan, etc. the system outputs information by multimedia hardware and software, and also provides inquiry through the man–machine interface.

183.4.3 Decision-Making Support System Based on Information Fusion

Building information fusion decision support system via information fusion model is based on different information structure models, constraint rules, probability functions. The decision support system can be divided into four parts: information fusion algorithm (core model), human-machine interaction subsystems (components), database subsystem (data components), model library subsystem (model parts) (Ford 2001).

(1) Information fusion algorithm
Information fusion algorithm is multi-level progressive structure. It needs to select the appropriate information fusion algorithm model according to the information structure in the planning and design of the actual decision-making support system. Information fusion structure model generally includes centralized, hybrid, and feedback.
(2) Human-machine interaction subsystem
Human-machine interaction part is a bridge between natural disaster decision support system and system users, it is responsible for passing the decision-making information which is entered by users to the system for processing, and also passes the results processed by the system to users or requires users to enter information in accordance with system requirements.
(3) Database Subsystem
The database Subsystem mainly plays the role of storing data, maintaining data and ensuring data security and effective. The system stores data types include system user data, user decision-making demanding data, historical monitoring data, disaster parameter data, rule-based reasoning data and other data.
(4) Model library and model library management system
The model library section includes data pre-processing model, attributes reasoning model, disaster identification model, disaster early warning model, decision support program development model and so on. Model library Management System section is mainly responsible for creating, modifying and deleting the models. And also is responsible for defining the new model and making data exchange the databases.

183.5 Conclusion

Based on the analysis of the seriousness of natural disasters and the plague mechanism, the paper integrates hi-tech such as multi-sensor technology, information fusion technology, adaptive technology and so on, and builds decision-making model and its supporting system for natural disaster emergency warning which provide powerful technology and system support for natural disasters detecting and warning. The system guarantees to make more promptly and accurate decisions in the natural disaster warning system, and it has significant meanings for improving natural disaster emergency level and reducing disaster losses.

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