Ershi Qi
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Proceedings of 2013 4th International Asia Conference on Industrial Engineering and Management Innovation (IEMI2013)

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Preface

Established in June 1990, the Chinese Industrial Engineering Institution (CIEI), CMES, is the first and unique national institution in the field of industrial engineering recognized by China Association of Science and Technology.

At present, CIEI announces an enormous number of experts, scholars and sub-societies. During the past 20 years, CIEI held dozens of domestic and international academic conferences, including quite a number of Hong Kong, Macao and cross-Strait industrial engineering forums and seminars. Sticking to the philosophy of “serving the country, serving the society, and serving the members”, CIEI has established profound cooperation with institutes and organizations from USA, England, Russia, Japan, Korea, Hong Kong, Taiwan and other countries or areas. CIEI currently possesses more than 20 local Institutions of Industrial Engineering, over 6,000 individual members and 136 corporate members.

The most distinguished characteristic of Academic Activities is The International Conference on Industrial Engineering and Engineering Management annually sponsored by CIEI. Being the most important international academic conference, it proves to be an advantageous platform for experts, scholars and business people in this area to exchange their theoretical and practical research views and results. Another second distinguished characteristic is The Enterprise Summit on the Application and Practice of Industrial Engineering held yearly. It aims to boost practical application of industrial engineering in production and to speed up the enterprise growth. Additionally, the Industrial Engineer Certification Working Group has been established to help novices to better and quicker adapt to the practice of industrial engineering; 24 training centers have also been authorized so that thousands of candidates are granted the license of “Qualified Industrial Engineer”.

The 4th International Asia Conference on Industrial Engineering and Management Innovation, held in Taiwan University, is another major international conference sponsored by CIEI. In the conference, some excellent scholars and specialists, both from home and abroad, as Keynote Speakers are to share their glory of achievement on scientific research and application in Industrial Engineering and Management Innovation. In the meanwhile, some parallel sessions are held in order that the authors can offer their opinions on the Theory and Technology of Industrial Engineering, Assistive Technology of Industrial Engineering and Management System Innovation. In a word, this conference aims to establish a platform for exchanging their theoretical research, achievement exhibition and practical exploration, to promote the development and application of theory and technology of this area in colleges and industries. We hope to promote the extensive cooperation and exchanges among the authors on the conference.

Finally, we would like to extend our sincerest thanks to the Department of Industrial Engineering, Taiwan University, for holding such an excellent event.

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Tianjin, People's Republic of China
July 2013

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Part I
Advanced Design and Manufacturing

Preparation of a Kind of Honey Effervescent Tablets

Ya-hui Zhang and Ze-yuan Huang

Abstract The aim of the research is to develop a kind of honey effervescent tablets. With honey power and pregelatinized starch as main raw materials, the matching accessories are chosen by the orthogonal test to select the production technology of the honey effervescent tablets. The optimized formula of the honey effervescent tablets is honey power 60 %, pregelatinized starch 15.5 %, citric acid 11.7 %, sodium bicarbonate 8.3 %, sodium cyclamate 2.0 %, PEG6000 2.5 %. The honey effervescent tablets prepared by this method which is simple and feasible, have stable quality and good taste, meet pharmacopeia standards, disintegrate rapidly and are easy to take.

Keywords Disintegrate • Effervescent tablets • Honey

1 Introduction

Since ancient times, honey is considered as a kind of very good food and drug and there are a lot of records in the ancient literature. Honey is composed of fructose and glucose and other sugars, easily absorbed by the body. In addition to containing sugar, honey also contains a variety of nutrients beneficial in normal function of cells and tissues, and organs. Honey has rich nutrition and great heat, with per kg mature heat yield about 12,560 joule. Honey has no fat, is perfect health tonic and is very suitable for the elderly, children, maternity and the sickness [1].

As a new dosage form in recent years, effervescent tablets are convenient to carry, distribute quickly in the water, with effective components easy to absorption and high bioavailability advantages. Effervescent tablets have the characteristics of both

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the solid preparation and the liquid preparation, have broad market prospects in pharmaceuticals and food industry. First of all, in addition to the main agents and excipients in the production of effervescent tablets, you can also add flavorings, sweeteners, coloring agents and excipients, etc., to improve the food flavor and develop a series of different flavors of effervescence food. Secondly, the effervescent has special disintegrants—effervescent disintegrants, disintegrate rapidly in cold water, help absorption and easier to take and carry than other formulations. The effervescent tablets form the food with delicious flavor and taste, instant ready to drink, especially to cater to the young people who love the new, extraordinary and special, has obvious advantages in the field of children and adolescents [2]. The honey effervescent tablets using honey as raw material made by this paper retain the nutrients and flavor of honey, rapid disintegration, good taste, convenient use and convenient carrying, long shelf life, become hot and cold can of carbonated beverage after dissolving, greatly increase the drinking interest.

2 Materials and Methods

2.1 Materials

Honey power (Hubei wuhan small bee food company), sodium cyclamate (Guangdong huasheng food chemical company in guangzhou branch), sodium bicarbonate (Beijing the odd century chemical trading company), citric acid (Hubei galactic chemical manufacturing company), pregelatinized starch (Tianjin peak starch development company), etc., are consumption level; absolute ethyl alcohol is of analytical grade, PEG6000 (Suzhou beautiful alum chemical industry trade company) is for medicinal level.

2.2 Instruments

TDP model sheet stamping machine (Shanghai tensho health station pharmaceutical machinery company), FA2104N analytical balance (Beijing ze xiang yongxing technology company), GZX-9070 mbe digital display blast drying oven (GZX-9070 mbe digital display blast drying oven), 78X-Z type tablet four eyes with meter (Shanghai yellow sea drug test instrument factory), YK-60 type granulator (Hunan ensure pharmaceutical machinery factory), WF130-30 universal mill (Changzhou music star drying equipment company).

2.3 *Preparation of Effervescent Tablets*

2.3.1 Technological Process

The Preparation of Alkali Particle

sodium bicarbonate
↓
honey power→mix→make soft material→dry→pelletize
↑ ↓
pregelatinized starch alkali particle

The Preparation of Acid Particle

citric acid
↓
honey power→mix→make soft material→dry→pelletize
↑ ↓
pregelatinized starch, sweetener acid particle

The Preparation of Effervescent Tablets

lubricant
alkali particle ↓
→ mix→ tablet → pack
acid particle ↑
pregelatinized starch, sweetener

The operation points. Take honey power, sodium bicarbonate, pregelatinized starch, sodium cyclamate and mix. Mixed with anhydrous ethanol spray, make the mixture can be molded into clusters, and can spread out, 20 mesh sieve, make soft material. In 50 °C drying box for drying, so that water is below 3 %. Twenty mesh to pelletize. Take honey power, citric acid, pregelatinized starch, sodium cyclamate and mix. Mixed with anhydrous ethanol spray, make the mixture can be molded into clusters, and can spread out, 20 mesh sieve, make soft material. In 50 °C drying box for drying, so that water is below 3 %. Twenty mesh to pelletize. Weigh the alkali, acid, PEG6000 and mix. Tablet in the tableting machine [3].

The formula design. The main factors affecting the effervescent tablets include sweetness, flavor, acidity of honey powder content, sweetener content etc. In order to meet consumer tastes, the content of sugar and acid in the effervescent tablets should be deployed. Sensory evaluation contains the color, smell, taste, shape, according to the results, determine the optimal formula [4].

Table 1 Honey effervescent beverage scoring reference standard

Color (20 score)	Smell (30 score)	Taste (30 score)	Posture (20 score)
Lvory without impurities (18–20)	Honey unique fragrance, rich (20–30)	Has the unique taste of honey (27–30)	Clear, without impurities, no separation (18–20)
Pale ivory without impurities (16–18)	Have fragrance, rich (24–27)	Has the unique taste of honey, suitable sweet and sour (24–27)	Without impurities, no separation (16–18)
Pale white, slightly impurity (below 16)	Have fragrance, light (below 24)	Honey taste is light, not palatable (below 24)	Light turbidity, impurity (below 16)

Determination of the quality indicators. Weight determination [5], according to inspection in accordance with the Chinese Pharmacopoeia 2005 edition an appendix I tablet weight difference. The disintegration test [5], check according to the Chinese Pharmacopoeia 2005 version of under disintegration effervescent tablets according to law. The measurement of pH [5], take three samples, plus 50 °C 100 mL water to dissolve, after 1 min, measure pH value according to the determination method of Chinese Pharmacopoeia 2005 version of an appendix VII. The amount of CO_2 in the effervescent [6], weigh the conical flask and 100 mL water and ten pieces of sample using weight precision loss method, record the total. The sample is added to the water, shaking with 20 min again precisionly weigh the conical flask until no bubbles emerge, record weight, the reducing weight is the amount of CO_2.

Sensory evaluation method. Using sensory evaluation method, use respectively by color, smell, taste, posture as the target of sensory evaluation [7] (Table 1).

3 Results and Discussions

3.1 Single Factor Experiment Done to Achieve Primary Influencing Factors of the Preparation Process

The determination of adhesive. Using absolute ethyl alcohol as adhesive, particle is not easy to agglomerate and dry quickly, products dissolve rapidly. Therefore, using absolute ethyl alcohol as adhesive, its effect is induced by the viscous and wetting tablet.

The determination of lubricant. Particles must be added lubricants before tableting with the purpose of avoiding weight variation, the sticking difficulties during the industrialized production of tablet, and maintaining tablets's smooth appearance which is convenient to tablet smoothly [8]. The referenceshows that the lubricant

Table 2 Test factors level table

	Factors			
Levels	A (%)	B (%)	C (%)	D (%)
1	15	55	1.5	2.0
2	20	60	2.0	2.5
3	25	65	2.5	3.0

PEG6000 has good lubricity, viscous resistance and water solubility [9]. So we choose PEG6000 as the lubricant, the single factor experiment was conducted to determine the amount of polyethylene glycol 2 %.

The determination of sweeteners. In order to improve the taste of honey effervescent tablets, we should choose the appropriate sweetener to eliminate pungent taste sour and to reach the appropriate sweet-sour ratio [10]. In the choice of the sweetener cyclamate, sodium cyclamate is a kind of common sweeteners, the sweetness is 50 times of sucrose. Sodium cyclamate belongs to the non-nutritive sweeteners, is generally not involved in glucose metabolism, but also can not be biodegraded, is suitable for patients with diabetes and obesity. It does not produce dental caries, its sweetener tastes better than the general sweeteners, and the single factor experiment was conducted to determine the adding amount is 2.5 %.

The determination of effervescent agent. Effervescent disintegrating agent is a kind of acid-base system that will produce carbon dioxide gas disintegration when mixed with water. Since citric acid taste mellow, soft, refreshing, delicious, we use citric acid as acid source. All things taken into consideration, choose citric acid and sodium bicarbonate as effervescent disintegrating agent [11]. In practical applications, the acid dosage should be larger than the amount of chemical reaction theory to ensure carbonate reaction completely and weak acid of the effervescent tablets, so as to change the effervescent tablets taste sense [10]. Using single factor test, the pH value and taste for evaluation, results show that, when the citric acid and sodium bicarbonate mass ratio was 1.4:1, the pH value is 4.5, the taste is best.

Orthogonal test to optimize the preparation process. According to the results of single factor test, screen factor A (effervescent disintegrating agent), B (honey powder dosage), C (PEG6000 content), D (sodium cyclamate content) and carry out orthogonal test, anhydrous ethanol added according to requirements, filler pregelatinized starch to maintain weight [12], evaluate the quality according to the sensory index score of finished products (Table 2).

The optimal level combination of flavor is $A_2B_2C_3D_1$, Factor D (sodium cyclamate content) as the least significant factors, its impact on flavor is small. Through calculation, the main formula for honey effervescents is honey power 60 %, pregelatinized starch 15.5 %, citric acid 11.7 %, sodium bicarbonate 8.3 %, sodium cyclamate 2.0 %, PEG6000 2.5 %. The weight of single tablet prepared by this recipe is about 1.50 g and the tablet releases a large amount of gas when solubling in 100 mL water, form transparent and white milky drinks which has honey fragrance, tasty sour and sweet (Table 3).

Table 3 Orthogonal test results and analysis

Serial number	A effervescent disintegrants (%)	B honey power (%)	C PEG6000 (%)	D sodium cyclamate (%)	Sensory score
1	1	1	1	1	60
2	1	2	2	2	73
3	1	3	3	3	75
4	2	1	2	3	72
5	2	2	3	1	86
6	2	3	1	2	79
7	3	1	3	2	74
8	3	2	1	3	76
9	3	3	2	1	78
K_1	208	206	215	224	
K_2	237	235	223	226	
K_3	228	232	235	223	
k_1	69.33	68.67	71.37	74.67	
k_2	79.00	78.33	74.33	75.33	
k_3	76.00	77.33	78.33	74.33	
R	9.67	9.67	6.67	1.00	

3.2 Verification Test

Select three batches preferably by orthogonal test results, the tablet disintegration time were 120, 130, 140 s. The effervescent tablet has sweet and sour taste, refreshing and aromatic taste, blister fast, has smooth appearance, uniform color and honey flavor. The experiment results show that this technological process is stable and feasible.

3.3 The Quality of Finished Products

Product color is white; morphology is round, the surface is smooth and appearance is neat; the aroma and taste has a little honey aroma, sweet and sour, soft taste; moderate hardness.

4 Conclusion

Through the above research obtained, the best formula of honey effervescent tablets is honey power 60 %, pregelatinized starch 15.5 %, citric acid 11.7 %, sodium bicarbonate 8.3 %, sodium cyclamate 2.0 %, PEG6000 2.5 %. The effervescent tablets prepared disintegrate rapidly, its hardness and foaming capacity are in line with the effervescent requirements, they have good appearance, uniform color, moderate hardness, disintegrate rapidly in cold water, good taste, suitable for all types of people, especially children and sickness.

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The Design and Research of a Kind of Timing Charging Controller

Li Ping and Jin-gang Xu

Abstract This paper is describing a kind of method which is based on SCM (model STC89C52) to design the software and hardware of a timing charging controller. It shows the working principle of the controller, and also focuses on the ways that read, write and operate the LCD module, clock chip, and the principle of turning a relay on or off, and it gives some pictures of the circuit principle diagram and the C language program code of the SCM.

Keywords Controller • SCM • Timing charging

1 Introduction

Since Chinese economic is developing steady and rapidly, the problem of the energy supply has appeared. The concept of green, low carbon, and saving energy has become more and more popular [1]. The rechargeable electric bicycle has entered into many ordinary families, the research and application of the electric cars has also gradually advanced.

People start to concern the problem of charging the storage battery and battery safely, overcharging is the most important thing that affect the life of the battery and storage battery. The controller designed in this paper can control the charging time accurately and prevent the overcharging [2].

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2 The Working Principle of the Controller

The SCM got the time information by reading the clock chip, the user can press the key to set an appointment charging time and the charging duration, the LCD display the setting time. After Setting, press the start key to charge. When the charging time is up, the single-chip microcomputer send a high frequency signal to the control end of the relay, then the control relay cut off the charging circuit, stop charging.

3 Design the Hardware

3.1 The Diagram and Picture of the System Hardware

As Fig. 1 shows the diagram and picture of the system hardware, it mainly includes the STC89C52 single-chip microcomputer, clock chip (DS12C887), the liquid crystal display module of Model 12864, buttons, relay, buzzer, and the master plate power [3].

A brief introduction of the Chip and electronic components:

1. The SCM of model STC89C52 is a kind of 8-bit microcontroller that has a high performance and low power consumption, it has 8 k chip program memory and 256 bytes chip data memory, the model of the kernel is 8051.
2. The clock chip of model DS12C887 can generate the time information such as century, year, month, day, minute and second automatically. It brings the lithium battery, when the external power cuts off, the internal time information can still maintain 10 years, and it has two different system modes: the 12 and 24 h system. AM and PM were used to distinguish the morning and afternoon; There are two ways to express the time, one is a binary number representation, and the other one is the BCD code.

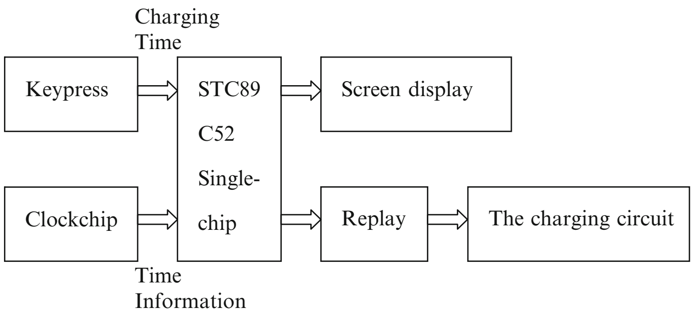


Fig. 1 The diagram and picture of the system hardware

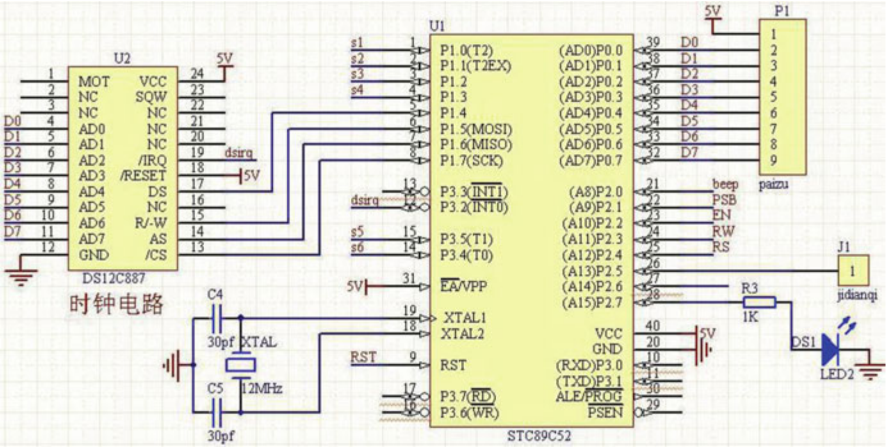


Fig. 2 The interface circuit of the Clock chip

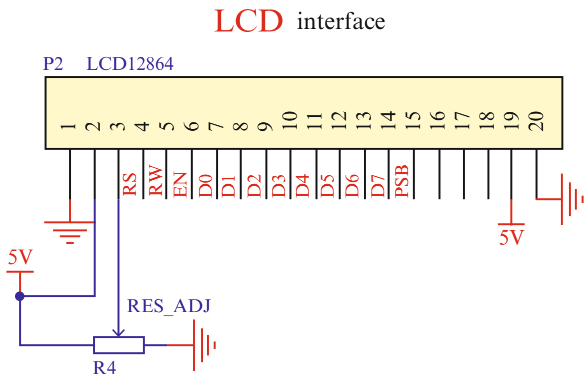
3. The model of the liquid crystal display module is 12864, it contains g simplified Chinese word stock, with 128 16 * 8 points ASCII character sets and 8192 16 * 16 point Chinese characters, there are four lines and each line shows 8 Chinese characters or 16 English characters. The interface is simple, and quite easy to operate, it constitutes the interface of the human-computer interaction system [4].
4. The relay using the dc control exchange model, the limited terminal voltage is 5 V dc high level signal, connected the output end with a 220 V mains ac circuit, both the control and output end have the protection of the light coupling isolation, and the noise to switch on and off is very low, it will not affect the normal work of the SCM weak current control system [5].

3.2 The Interface Circuit Design of the Single-Chip Microcomputer and Clock Chip DS12C887

Figure 2 has shown the principle of the clock chip interface circuit. Inside the DS12C887 there is a crystal oscillator which eliminates the need of the external crystal oscillator. The AD0–AD7 is a signal wire. Through a 10 k pull-up resistor, each can be connected to the ports P0.0–P0.7 of the SCM. MOT tube feet up has decided the Intel work mode system of the clock chip, and the DS pin can be read when the input end is using it.

R/W pin allowed to be used as write in the Intel work mode. AS is the inputting foot of the address gate, when reading and writing, the rising edge of AS will latched the address information which appeared on AD0∼AD7 on to DS12C887. CS is a piece-selected input end, when this pin is at a low electric frequency, DS12C887 works [6].

Fig. 3 The interface circuit of the 12864 LCD module



When welding and drawing the circuit diagram, we should pay attention to the following aspects: capacitance C4, C5 and crystal oscillator XTAL should near to the XTAL1 and XTAL2 end as close as possible, and apply copper surround it, minimum the leading of the electromagnetic interference by the wire, and get the system operating frequency of higher precision as far as possible [7].

3.3 Single-Chip Microcomputer and the Interface Circuit Design of the 12864 LCD Module

There is a single-chip microcomputer and the interface circuit principle diagram of the 12864 LCD module in Fig. 3. In this picture the "D0–D7" is the data port of the LCD module. It respectively connect to the P0.0–P0.7 of the single-chip microcomputer through a 10 k pull-up resistors for passing the signal data of the LCD module and the order data. RS end is the choosing end of the "data/orders". When the electric frequency is high, D0–D7 passes the signal data; when the electric frequency is low, D0–D7 passes the signal data [8].

RW is a choosing end for "read/write". When the electric frequency is high, the single-chip microcomputer read the LCD data; when the electric frequency is low, the single-chip microcomputer will write the data into the LCD. EN is a possible end, when the electric frequency is high, the LCD module and the single-chip microcomputer exchange the information. PSB is a selection end for the serial/parallel working mode, the system adopts the parallel way to pass the data, so PSB should be fixed to join the high electric frequency. The pin jumper 2 and 3 connect to a precise adjustable resistance of 10 k ohm. It can adjust the brightness of the LCD module display through changing its resistance [9].

4 The Design of the Program

The program of the timing charging controller is mainly includes three parts: the reading and writing program of the DS12C887 clock chip, the on-off procedures of the relay, the interactive program (that is the liquid crystal display and the key input program) [10].

4.1 The Procedure Chart

After the electric is connected to the system, the microcontroller reset initialization register and the peripheral devices will read the clock chip, and displayed the time information on the LCD. At the same time, the system is waiting for the key operation from the user. And the users can adjust the time through pressing the key, set the charging time and charging duration in advance, then after pressing the ok key, the system will start to count down (Fig. 4).

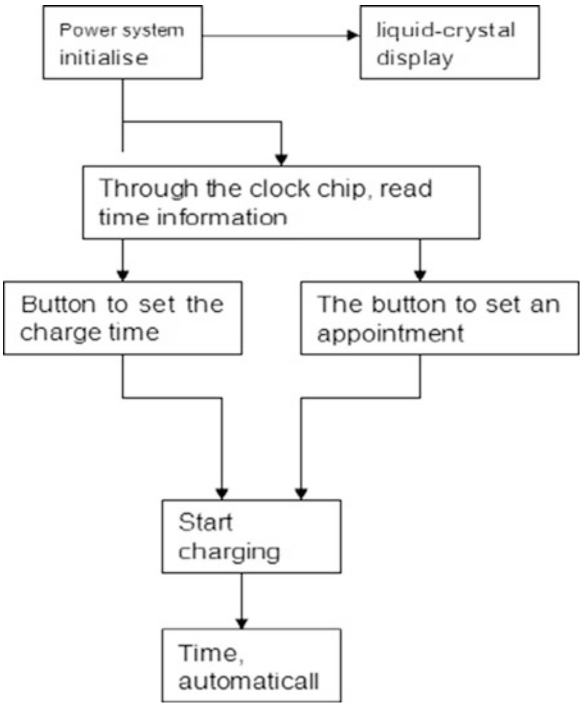


Fig. 4 The procedure chart

When the appointment time is up, the will send a high frequency signal to the control end of the relay, the relay will close the charging circuit and start to charge [11]. When the charging time is up, the single chip microcomputer will send a low frequency signal to the control end of the relay, and the relay will cut off the charging circuit, then the charging is over [12].

4.2 The Reading and Writing Program of the DS12C887 Clock Chip

The rule of reading and writing operation of DS12C887 is to send the address first, and then read the data. The following is the complete code and note to read the clock data:

```
Unsigned char read_ DS12C887 (unsigned char add) / /
  read the clock data
Unsigned char ds date; / / defined variables, it is
  used to store the clock data
     dsas=1;
     dsds=1;
     dsrw=1;
dscs = 0; / / DS12C887 temporarily stop to interact
  with the single-chip microcomputer
P0 = add; / / send the address of the data will be read
  into DS12C887
dsas = 0; / / clean the address be sent
DSDS = 0; / / prohibited the reading operation
P0 = 0 XFF; / / initialize all the clock signal wire to
  a high frequency
Ds_date = P0;
DSDS = 1; / / start to the reading operation
Dsas = 1; / / set high, allow to receive the next
  address information
DSCS = 1; / / allow DS12C887 to send the information
  to the single chip microcomputer
Return (ds_date); / / return to the reading clock data
  [13]
```

4.3 The Reading and Writing Program of Model 12864 LCD Module

The reading and writing rule of the Model 12864 LCD module is: write a command first, then write the data. The following is the complete code and note of the data son function [14]:

```
Void write_lcd_date (unsigned char date) / / write the
  son function of the LCD data
Lcd_RS = 1; / / chose the operating way to write
Lcd_RW = 0; / / open the function of writing LCD
Lcd_EN = 0; / / liquid crystal break-off
P0 = date; / / will wait for sending into the display
  data
Delay (5); / / delay for 5 millisecond, and wait for the
  data delivering completely
EN = 1;/ / liquid crystal start to work, display
delay (5);
EN = 0; }
void Lcd_display(unsigned char shi,fen,miao)
```

Then establish the liquid crystal display subfunction, and complete the displaying function:

```
Void Lcd_display (unsigned char shi, fen, miao)
{write_shifenmiao (6, miao); / / write the second to
  the second-line second position of the liquid crystal
Write_shifenmiao (4, fen); / / write the minute to
  the second-line minute position of the liquid crystal
Write_shifenmiao (2, shi); / / write the hour to the
  second-line hour position of the liquid crystal}
```

4.4 The Action Program of the Relay

When the control end of the relay get the high electric frequency, the output end closed, or the output end off.

```
Void jidianqi_ctrl () / / The on and off of the relay
  control the sub-procedure [15]
```

```
{If (shi = = dian) and & (xiaoshi! = 0) / / the
  reservation time is up
{Jidianqi = 1; / / the circuit of the relay is on,
  start to charge
If (shi = = (dian + xiaoshi) | | (shi = = (dian +
  xiaoshi - 24))) / / the charging time is up, stop
  to charge
{Jidianqi = 0; / / the circuit of the relay is
  disconnected, stop charging}}
else {Jidianqi = 0; / / other time periods, prohibit
  to charge}}
```

5 Conclusion

This paper studies the software and hardware problems of the timing charging controller in design by using the devices of the single-chip microcomputer, the clock chip, the relay and the liquid crystal display module. It also designed the hardware circuit of the controller completely, detailed explained the key program code, and has received the expected effect by building the hardware system through the all purpose circuit and the testing experiment.

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Models and Algorithms for Locating Facilities with Hybrid Demand for Service

Rui-ling Shen, Jia-zhen Huo, and Xu-fang Li

Abstract We developed a new model for locating facilities with demand that are originated from both residential areas and from passing by flows. A mixed integer program is proposed with the objective function of maximum the total profit gained by serving both types of customers. Since the problem is NP-hard, greedy heuristic and improved greedy heuristic are proposed. The improved greedy heuristic presented solves the computational experiments with competitive results, while the run time is much less than that of the optimal method. The sensitivity of the optimal locations to the input parameters is analyzed with an example network and the results are reported.

Keywords Facility location • Flow-interception • Greedy heuristic • Hybrid demand

1 Introduction

The study on facility location problems has made great progress in recent years, the classical location models and the flow interception models are the most common models for optimal facility location problems. The classical location models assume that the demand for service are all originated from nodes of the network [1], customers should make a special purpose trip to the facility if they want to get the service, are mainly with the objective function of minimizing the

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total weighted travelling distance (p-median problem), minimizing the maximum traveling distance (p-center problem), and maximizing the total demand covered by location facilities (maximal covering problem). The flow interception problem assumes that the customers are traveling on a pre-planned trip between origin-destination (O-D) nodes, customers may obtain service if they pass through a facility, is mainly with the objective function of maximizing the flows that can be intercepted.

Most of the facility location models assume that the demand for service are exactly one type, customers are exclusively from passing by flows in flow interception models, while they are exclusively from residential areas in classical location models. But in reality, the demand for many retail facilities are of “hybrid” type, partially from special trip purchases and partially from by-passing customer flows [2]. Fox example, gasoline stations, convenience stores et al., serve customers from both residential areas and passing by customers. A web-based survey on driver’s behavior shows that 69.6 % of drivers select to refuel near home or workplace, while the other 30.4 % drivers randomly select station during their driving. So, it’s necessary to take both types of customers into consideration in retail facilities location problems.

Few of precious facility location literatures considered the two types of demand simultaneously. Goodchild and Noronha [3] first recognized the problem, they formulated a multi-objective programming model to site a finite number of gasoline outlets after merger with another company, used the p-median objective of rationalizing stations from existing station networks, and the second objective of locating stations on high-traffic lines to maximize the sum of traffic flows passing by all stations. The traffic-count methods they used, however, may count the same trip multiple times, even if the drivers only refuel once, and thus they could recommend locating stations on consecutive links of a busy highway [4, 5, 6]. Hodgson [7] and Berman et al. [8] independently developed flow based facility location models, known as “flow capturing location model (FCLM)” and “flow interception location model (FILM)”. The models eliminate the double counting by using path flows instead of link flows. Hodgson and Rosing [9] combined the FCLM and p-median model together, presented a hybrid model with two conflicting objectives, namely minimum the aggregate weighted demand distance and maximum flows to be captured. They found that the p-median model is more easily be influenced by the flow capturing objective than the reverse. Berman [10] classified customers into two types: those whose demand for service originates from nodes as “neighborhood customers”, and customers from travelling on the network as “flow customers”, and formulate four coverage location models considering both of the flow demand and the nodal-demand, in the first two problems, the focus is on the coverage of potential customers, while the other two models emphasis on the expected number of potential customers who actually become users. Erdemir et al. [11] developed two coverage models that allows for both nodal and path coverage, the first one (explicit model) is formulated as a Quadratic Maximal Covering Model (QMCM) and the other one (implicit model) is a geometric approach, and then illustrate the models on cellular base stations location in Erie County, New York city, USA. Erdemir [12] then use the explicit model to find optimal aeromedical base locations for the state of New Mexico, in which crash nodes correspond to a set of points at which accidents occur frequently, while crash paths correspond to roads on which occur not only at a specific point, but also at some location along the path.

Melaina [13] summarized the history of the US gasoline retail infrastructure, suggested some general criteria for identifying effective locations for early hydrogen stations: located close to high traffic volumes, in high profile areas to increase public awareness, near the potential first fuel-cell vehicle buyers, in places to provide fuel for customers with long distance trips. Two types of initial hydrogen stations fulfill these criteria: stations located in metropolitan (satisfying 1–3) areas serve residential customers and stations located along interstate highways (satisfying 1, 3, 4) serve passing by customers. Wang and Wang [14] developed the idea, proposed a two objective mixed integer program (minimum total location cost and maximum population coverage), and applied the model to the case of fast-refueling station planning on Taiwan's road network.

In this paper, we intend to develop a location model for facilities of which serving customers partially from residential areas (node-based demand), and partially from by-passing flows (flow-based demand). The paper is organized as follows: a mathematical model deals with the problem is presented in Sect. 2, Sect. 3 gives greedy heuristic and improved greedy heuristic designed to solve the model, the results of a series of computational experiments aimed at assessing the performance of heuristic algorithms are given in Sect. 4, the sensitivity analysis are given in Sect. 5, and Sect. 6 contains the conclusions of the study.

2 Mathematical Model

G (N, A) N, set of nodes, A, set of arcs
P Set of paths with non-zero flows, $p \in P$
N_p Set of nodes on path p
f_p Flow on path p, $p \in P$
λ The average profit by serving per flow-based customer
μ The average profit by serving per residential customer
ω_j Demand at node j

$$y_j = \begin{cases} 1 \text{ if we locate a station at node } j & j \in N; \\ 0 & \text{otherwise} \end{cases}$$

$$x_p = \begin{cases} 1 \text{ if the flow on path } p \text{ is intercepted} & p \in P; \\ 0 & \text{otherwise} \end{cases}$$

In this paper, we assume: (1) the node-based demand customers and the path-based demand customers represent different types of customers, they are additive and there is no double counting; (2) the demand at node j can be satisfied only if there is a station located at j; (3) the flow on path p can be intercepted only if there is at least one facility located on the nodes of path p; (4) all nodes are available to locate new stations; (5) only one facility can be located at each node.

We can formulate the problem as follows:

$$\text{Max} \sum\nolimits_{\mathrm{p}\in\mathrm{P}} f_p \cdot \mathrm{x_p} \cdot \lambda + \sum\nolimits_{\mathrm{j}\in\mathrm{N}} \omega_j \cdot \mathrm{y_j} \cdot \mu \tag{1}$$

$$\text{s.t.} \sum\nolimits_{\mathrm{j}\in\mathrm{N}} \mathrm{y_j} = m \tag{2}$$

$$\sum\nolimits_{\mathrm{j}\in\mathrm{N_p}} \mathrm{y_j} \geq \mathrm{x_p} \quad \mathrm{p} \in \mathrm{P} \tag{3}$$

$$\mathrm{y_j} \in \{0, 1\} \quad \mathrm{j} \in \mathrm{N} \tag{4}$$

$$\mathrm{x_p} \in \{0, 1\} \quad \mathrm{p} \in \mathrm{P} \tag{5}$$

The objective function (1) is to maximize the total profit, the first part of it represents the profit by serving flow-based customers, the second part represents profit by serving residential customers; constraint (2) assures that there are *m* new facilities to be located; constraint (3) ensures that the flow on path p can be intercepted only if there is at least one facility located on path p; constraint (4) and (5) are binary requirements.

3 Heuristic Algorithm

Greedy heuristic is a step-by-step method to solve a problem, it adds the node that maximum the objective function at each stage and makes the best choice at each iteration. The disadvantage of the algorithm is that it may ultimately yield local optimal solution other than global optimal solution, but it fails to produce the global optimal solution in many cases. In decent heuristic, the neighborhood of a set S is defined as adding a node to S and removing another node from it. Borrow the concept of 'neighborhood' in decent heuristic; we propose the algorithm to improve the solution gained by greedy heuristic. The algorithm is divided into two stages:

Stage 1: Greedy heuristic

Step 1: k = 1; let E be the set of nodes obtained by greedy algorithm, M be the nodes that not be obtained, obviously, E = Φ, M = N in the initial state;
Step 2: Choose one node at every turn from set M sequentially, and with the node in set E, calculate the objective function (1), let j* be the node that maximum the objective function (1);
Step 3: $E = E \cup \{j^*\}$, $M = M - \{j^*\}$, $k = k + 1$;
Step 4: stop the algorithm if k = m or E = N, otherwise go to step 2.

Stage 2: t_{max} denotes the maximum iterating times, and the steps are as follows:

Step 1: $t = 0$; E denote the set of nodes obtained from Greedy Algorithm, $M = N - E$;
Step 2: $t = t + 1$; $\forall\, a \in E, b \in M$, substitute a for b and recalculate the objective function (1);
Step 3: if the objective function value is improved, $E = (E - \{a\}) \cup \{b\}$, $M = (M - \{b\}) \cup \{a\}$;
Step 4: if $t = t_{max}$, stop; otherwise go to step 2.

4 Computational Experiments

We conduct series of computational experiments in this section. The experiments were designed to test the performance of the algorithms described in Sect. 2. All algorithms were coded using Matlab 7.0 [15], and all experiments were run on an Intel Core i3-350 personal computer.

The test examples were generated as follows: given the input parameters n, the number of network nodes, equals to 10, 20, 25, $||p||$, the number of path with non-zeros flows, equals to n, and m, the number of new facilities to be located, equals to 2, 3, 4, 5. f_p is randomly generated in [0, 100], ω_j is randomly generated in [0, 300], let $\lambda = \mu = 1, t_{max} = 500$. We randomly generate 10 test examples for every input parameter, altogether, 100 different cases were solved.

The results are shown in Table 1. The first two columns are the values of the input variables, the column 'GOs' contains the times of getting the optimal solution by greedy heuristic in ten test examples, 'G_mean' contains the mean relative error between the greedy heuristic solution and the optimal solution, in the same way, the comparisons between the improved greedy heuristic solution and the optimal solution are given in columns of 'IGOs', 'IG_mean', 'GRT' contains the average run time of the greedy algorithm, 'IGRT' contains the average run time of the improved greedy heuristic and 'ORT' contains the average run time of the optimal solution. Here, we denote relative error $= \frac{\text{optimal solution} - \text{heuristic algorithm solution}}{\text{optimal solution}}$.

As we can see from Table 1, the probability of greedy heuristic yields to global optimal solution decrease quickly with the increase of the number of new facilities to be located, the improved greedy heuristic, although cannot guarantee to get the optimal solutions, obviously get better results than that of greedy heuristic. Both heuristic algorithms have shorter run time, while the run time of optimal solution increasing quickly with the values of input variables increase. Overall, the operation of improved greedy heuristic is the best.

Table 1 Comparisons between heuristic algorithm solutions and optimal solution

m	n	GOs	G_mean	IGOs	IG_Mean	GRT	IGRT	ORT
2	10	8	0.0063	10	0	0.182	2.944	3.019
3	10	7	0.0186	9	0.0027	0.183	2.977	3.099
2	20	9	1.6e-004	9	1.6e-004	0.295	3.072	6.263
3	20	8	0.0075	10	0	0.281	3.106	6.485
4	20	8	0.0014	9	7.8e-004	0.301	3.090	7.909
5	20	6	0.0206	9	0.0036	0.312	3.118	27.937
2	25	10	0	10	0	0.379	3.089	103.275
3	25	10	0	10	0	0.372	3.170	104.031
4	25	7	0.0124	10	0	0.383	3.183	119.937
5	25	7	0.0111	10	0	0.394	3.179	401.648

Fig. 1 Example network

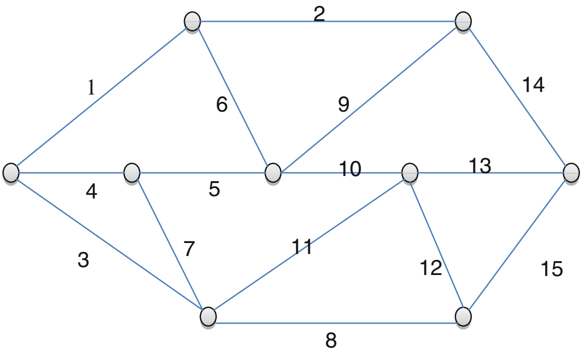

Table 2 The flow on each path

No	Paths	Flows	No	Paths	Flows
1	1, 6	49	9	4, 10	91
2	6, 10	69	10	4, 12	62
3	1, 7	82	11	7, 12	14
4	1, 3	73	12	11, 12	55
5	3. 4	37	13	12, 15	84
6	4, 6	34	14	10, 15	24
7	3, 7	58	15	11, 15	27
8	7, 11	60			

5 Sensitivity Analysis

Two factors that might affect the computational results of the problem are studied, namely the respective demand f_p, ω_j, and the respective average profit by serving per demand λ μ. We refer to an example of a network with 15 paths depicted in Fig. 1. The corresponding flow values are shown in Table 2 and the demand of each node are shown in Table 3.

Table 3 The demand on each nodes

Nodes	Demands	Nodes	Demands
1	48	9	168
2	69	10	45
3	180	11	99
4	198	12	69
5	225	13	282
6	144	14	66
7	213	15	102
8	201		

Table 4 The results of fix $\mu = 1$

m	λ	IGR	OAR	m	λ	IGR	OAR
1	0	13	13	2	0	5,13	5,13
	0.2	13	13		0.2	7, 13	7, 13
	0.8	7	7		0.8	7, 13	7, 13
	1	7	7		1	4,7	4,7
	2	7	7		2	6,7	6,7
	5	7	7		5	6,7	6,7
	10	7	7		10	6,7	6,7
3	0	5, 7, 13	5, 7, 13	4	0	5, 7, 8, 13	5, 7, 8, 13
	0.2	4, 7, 13	4, 7, 13		0.2	4, 5, 7, 13	4, 5, 7, 13
	0.8	4, 7, 13	4, 7, 13		0.8	4, 5, 7, 13	4, 5, 7, 13
	1	4, 6, 7	4, 6, 7		1	4, 6, 7, 13	4, 6, 7, 13
	2	4, 6, 7	4, 6, 7		2	4, 6, 7, 15	4, 6, 7, 15
	5	6, 7, 15	6, 7, 15		5	4, 6, 7, 15	4, 6, 7, 15
	10	6, 7, 15	6, 7, 15		10	4, 6, 7, 15	4, 6, 7, 15

As we set $\lambda = \mu = 1$ in the last section, from function (1) we can see that the computational results of λ (or μ) varies from 1 to α (or β) is exactly the same as that of the values of f_p (or ω_j) changes to $\alpha \cdot f_p$ (or $\beta \cdot \omega_j$). So we just analyze the sensitivity of the optimal locations to the values of λ and μ.

Fix $\mu = 1$, values of λ: 0, 0.2, 0.8, 1, 2, 5, 10, respectively, are tested over the network depicted above. The results of optimal and the improved greedy heuristic are shown in Table 4, the results of fix $\lambda = 1$, values of μ: 0, 0.2, 0.8, 1, 2, 5, 10, are shown in Table 5. In Tables 4 and 5, the column 'IGR' contains the optimal location nodes gained by improved greedy heuristic, the column 'OAR' contains the optimal location nodes gained by the optimal solution. From Tables 4 and 5, the following observation can be made:

1. The results of λ varies from 0 to 10 and the results when μ changes from 10 to 0 are proportional. Mathematically, this is a certain result. When $\lambda = \alpha$, $\mu = 1$, the objective function (1) $= \sum_{p \in P} f_p \cdot x_p \cdot \alpha + \sum_{j \in N} \omega_j \cdot y_j \cdot 1 = \alpha \cdot (\sum_{p \in P} f_p \cdot x_p \cdot 1 + \sum_{j \in N} \omega_j \cdot y_j \cdot 1/\alpha$), from the equation we can see that, the location decision of $\lambda = \alpha, \mu = 1$ must be identical to the decision when $\lambda = 1, \mu = 1/\alpha$, and the total profit gained by the latter case is $1/\alpha$ of that of the former. So next we only need to analyze the computational results in Table 4.

Table 5 The results of fix $\lambda = 1$

m	μ	IGR	OAR	m	μ	IGR	OAR
1	0	7	7	2	0	6,7	6,7
	0.2	7	7		0.2	6,7	6,7
	0.8	7	7		0.8	6,7	6,7
	1	7	7		1	4,7	4,7
	2	7	7		2	7, 13	7, 13
	5	13	13		5	7, 13	7, 13
	10	13	13		10	5, 13	5, 13
3	0	6, 7, 15	6, 7, 15	4	0	4, 6, 7, 15	1, 7, 10, 12
	0.2	6, 7, 15	6, 7, 15		0.2	4, 6, 7, 15	4, 6, 7, 15
	0.8	4, 6, 7	4, 6, 7		0.8	4, 6, 7, 15	4, 6, 7, 15
	1	4, 6, 7	4, 6, 7		1	4, 6, 7, 13	4, 6, 7, 13
	2	4, 7, 13	4, 7, 13		2	4, 6, 7, 13	4, 6, 7, 13
	5	4, 7, 13	4, 7, 13		5	4, 6, 7, 13	4, 6, 7, 13
	10	5, 7, 13	5, 7, 13		10	5, 7, 8,13	5, 7, 8,13

2. The optimal location decisions remain unchanged when $\lambda \in (0,1)$ or $\lambda > 1$. When the values of λ is much smaller than that of μ, the profit gained by intercepting path flows provide only a tiny proportion of the total profit, location decisions are made mainly from the condition of the residential demand of each node; with the increase of values of λ, the profit gained by intercepting path flows increases sharply, the flow-based demand cannot be ignored, and we should take the both types into consideration when make decisions, the optimal solutions changed several times, finally, with the continuing increase of the value of λ, opposite to the situation of the beginning, the profit gained from serving residential areas can be ignored, location decision stopped change.
3. When $\lambda = 0$, the first part of function (1) equals to zero, the problem is transformed into a p-median problem, similarly, the problem is transformed into a flow interception problem when $\mu = 0$. We can inquire the location decisions of the two cases in Tables 4 and 5. And from Tables 4 and 5, we can see that the model formulated only considering one type of demand is unilateral if the demands are hybrid, this may lead to locally optimal solution.

The solutions of improved greedy heuristic are the same as the optimal solutions, while the improved greedy heuristic is much faster than that of the optimal algorithm, so we recommend the improved greedy heuristic for medium- or large-sized network solutions.

6 Conclusion

In reality, the demand for many retail facilities may originate from both residential area customers and from intercepting customers passing by the facility. Gasoline stations, convenience stores, fast food outlets, ATMs et al., fall into this category.

The enterprise should take both types of customers into consideration during the site selection process. In this paper, we developed a mixed integer program for facilities with this two types of demand customers, the objective is to maximize the total profit from serving both types of customers, greedy heuristic and improved greedy heuristic are proposed to solve the problem. The improved greedy heuristic presented solves the computational experiments with competitive results obtained, especially with CPU times consumed being much less than those of the optimal approach. We also analyze the sensitivity of the optimal locations to the input parameters with an example network.

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The Complexity Conceptual Model of Lean Construction

Chun-ping Huang, Pu Liu, and Pei Zhang

Abstract Nowadays the construction industry is one of the largest and most important industries. The paper firstly reviews the history of Lean construction, two main theory- TFV and LPDS. Then it analyzes the complexity of construction that it differs from manufacture. Finally, combining with stimulus-response model of CAS theory, conceptual model of Lean construction is proposed.

Keywords CAS theory • Conceptual model • Lean construction • Complexity

1 Introduction

Nowadays, China's economy is in rapid development period. With the regulation of national economic policy and investment structure, particularly in the background of expanding domestic demand and increasing investment in infrastructure to promote economic development, it provides good opportunities for the construction industry. As a pillar industry in national economy, the construction industry has strengthened increasingly. However, the increase in China's construction industry output value mainly relies on cheap labor (such as migrant workers). Its labor productivity is much lower than that of the United States, Japan and other countries. The growth mode is extensive [1]. In addition, modern projects involves a large scale, new technologies, multi-units and fine divisions, it requires us to apply the appropriate theory, method and means to the construction site management. The management personnel should be specialization and the management work should be standardized with Chinese characteristics. Lean construction is put forward under such background. Lean construction is an adaptation and a supplementary of the

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Japanese lean production principles in the construction process [2]. In this paper, based on the adaptability of the CAS theory, it presents a theoretical framework of lean construction, attempts to provide a theoretical basis for improving productivity in the construction industry.

2 Review of Lean Construction

2.1 History of Lean Construction

Lean construction comes from lean production developed in the 1950s by engineer Ohno at Toyota. Lean production' aim is to shorten the cycle time to get products to market by minimizing waste. According to engineer Ohno, this new production philosophy should provide [3]:

- A uniquely custom product
- Instant delivery with minimum inventory
- Production with zero waste

Generally, Manufacturing plants and construction sites are different in many ways that might explain why lean production theories and practices do not fully fit the construction industry [4]. Therefore, the construction industry has rejected many ideas from manufacturing because of the belief that construction is different. Manufacturers make parts that go into products, but the design and construction of unique and complex projects in highly uncertain environments under great time and schedule pressure is fundamentally different.

The movement to apply the concepts of LPS to the construction industry was started by several researchers. Koskela claimed that the traditional conversion production system would be required to change to the new lean concept of the flow production system, and this would improve efficiency in the construction industry [5]. Since then, much research on lean construction has been conducted. Womack and Jones use of 'lean thinking' as the generic term to describe application beyond manufacturing [6]. Lean thinking comprises a complex bundle of ideas including continuous improvement, flattened organization structures, the elimination of waste, teamwork, the efficient use of resources and cooperative supply chain management. The current institutes focusing on the lean ideas are the International Group of Lean Construction (IGLC) founded in 1993 and the Lean Construction Institute (LCI) founded in 1997. Lean construction is a production management-based project delivery system emphasizing the reliable and speedy delivery of value. It challenges the generally accepted belief of a trade-off between time, cost and quality [7].

Since 1993, two major lines of thinking have governed the work on lean construction [8].

One is Koskela's Transformation-Flow-Value (TFV) concept and the other is Ballard and Howell's Last Planner methods of production control. To date most

U.S. construction companies have followed the Last Planner methods to improve performance. In addition to the Last Planner methods, the Lean Construction Institute has developed another way to design and build capital facilities by reforming the management of production. The LCI calls that new way the Lean Project Delivery System, LPDS. The detail interpretations about Koskela' TFV and LPDS will be shown as follows.

2.2 Transformation-Flow-Value Generations (TFV)

Koskela introduced a new unified theory of production, termed as the Transformation-Flow-Value Generation (TFV) [5]. This theory is an integrated theory developed from the three main production paradigms namely; Craft production, Mass production, and Lean production. The TFV theory can be defined as follows [9]:

- Transformation view-Concept of transforming inputs to outputs.
- Flow view-Materials and information flow in a production process.
- Value generation view-Process where the value for customer is created through fulfillment of his/her requirements.

2.3 The Lean Project Delivery System (LPDS)

LPDS applies principles pioneered in manufacturing to construction. LPDS tools facilitate planning and control, maximizing value and minimizing waste throughout the construction process. Its model consists of 11 modules, organized into five interconnecting triads or phases extending from project definition to design to supply, then assembly and use. The LPDS also has a production control module and a work structuring module, both conceived to extend through all project phases, and learning loops, which is a post-occupancy evaluation module that links the end of one project to the beginning of the next. Learning is a process that occurs in cycles, thus the learning loop is incorporated at every level, and dedicated to rapid system adjustment. Figure 1 presents the diagram of LPDS developed by the LCI. The LCI also defined the concepts and principles of lean construction as follows:

Lean construction is a new way to design and build capital facilities. Lean theory, principles and techniques, taken together, provide the foundation for a new form of project management.

Furthermore, several studies even argue that Lean shows a impact on construction. For example, Thomas et al. investigates the lean principle and using data from three projects covering 137 workdays, this paper has shown that there is validity to the lean construction principle that effective flow management can improve construction labor performance [10]. Halpin and Kueckmann explore the relationship between simulation and the emerging topics of Lean Thinking and lean

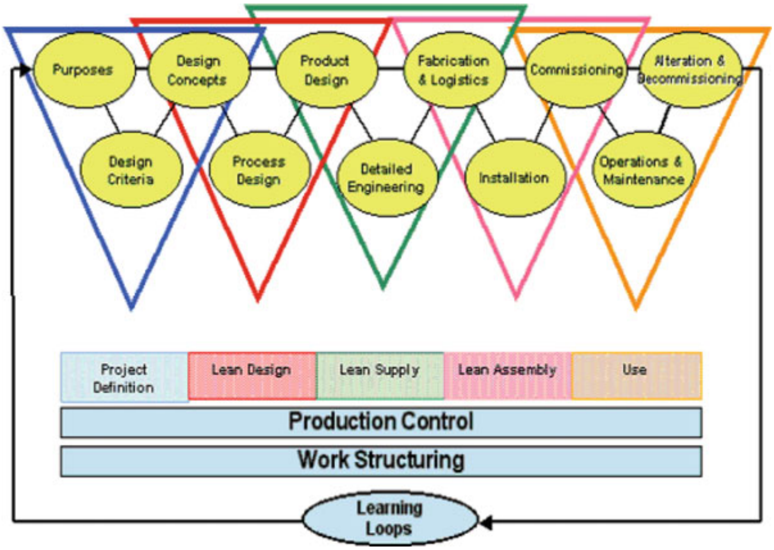

Fig. 1 Lean Project Delivery System [8]

construction. Then they discussed the use of simulation as a means of evaluating the benefit of using lean construction techniques [11]. Stuart and Susan animadverts the existing literature on lean construction is overwhelmingly prescriptive with little recognition of the social and politicized nature of the diffusion process, and conducted 25 interviews with construction sector policy-makers between May 2001 and April 2003 [12]. And then he considers that 'leanness' can be conceptualized in terms of a quest for structural flexibility involving restructuring, downsizing and outsourcing. Jin-Woo Bae and Yong-Woo Kim argue lean construction methods impact the sustainability of high performance facilities and to suggest how these Lean construction methods evolve to contribute to green construction [13].

3 The Characters of Construction

The construction industry has three other features that distinguish it from manufacturing: On-site production, one-of-a-kind projects, and complexity (i.e., temporary multi-organization and regulatory intervention) [14].

On-site production: Construction is site-position manufacturing. In construction, installation and erection are the activities that most increase the value of the product. The contractor must ensure that all components assembled on site meet high-quality standards that are greatly influenced by specific site conditions.

One-of-a-kind production: Firstly, the production is unique. Any two products are different. Normally manufacturing takes advantage of specialized equipment to

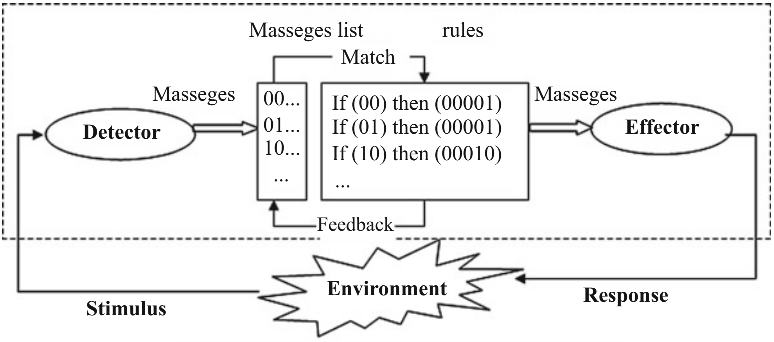

Fig. 2 Sketch map of the stimulus – response model

make standardized units, allowing only a limited level of customization by retailers. In construction, customers play a key role throughout the project cycle. Under guidance from the designer, customers define their product explicitly through the bid package or contract. The owner or the owner's representative can modify the requirements and details of the contract by addenda (before bids are opened) or change orders (once the bid is closed).

Complexity: In manufacturing, many components from different subassemblies can be easily managed because suppliers are selected early in the design phase. Specialized facilities with suitable technology and layout ensure the reliable flow of the product. With repetition, this supply network eventually becomes manageable and optimized. In contrast, in construction, the completion of activities is highly interrelated and complicated. Construction projects are characteristically complex, unique, dynamic systems that must rely on an initial design that involves a number of subassemblies with variable specifications [15]. Being an on-site production, the installation of those subassemblies is constrained by the interacting and overlapping activities of different contractors, making it more difficult to meet a fixed schedule.

Construction process is complex. This will give emphasis on flow function when researching on transferring single construction activity to how to link the activities.

The combined effect of on-site, one-of-a-kind, and complex production is uncertainty.

Additionally, this paper considers hierarchy is also one of the key features. Randolph Thomas et al. provided a model of construction hierarchy and focus on the Workflow in Construction [16]. As Fig. 2 shows, there are three cycle times that can be discussed depending on the level of one's interest. Three cycle times include total process level (craft), activity or task level (crew) and subtask or method level (group or individual).

Because of above mentioned four features, the construction process is particular and cooperative. It needs all the members to cooperate and study adaptively, and then their common goal will be achieved [17, 18].

4 The Conceptual Model of Lean Construction Based on CAS Theory

4.1 Brief Introduction to CAS Theory

The term complex adaptive systems is often used to describe the adaptive and active system, such as the economics, ecology, immune system, embryo, nervous system, the computer network and so on. Complex Adaptive System (CAS), which is based on John H. Holland's research on complex system, was put forward in 1994 [19].

The kernel concept of CAS is "Adaptation Builds Complexity". CAS puts emphasis on agent's initiative. The agent changes its behavior in response to its environment. The adaptive change that occurs is often relevant to achieving a goal or objective.

The most significant contribution of CAS theory is it connects the Stimulus-response model. The interaction of agent and environment makes the change of the agent become the foundation of system's change, and then the two changes can be studied together.

Based on the above mentioned two models, CAS includes the detection system, the performance system and the response system (as shown in Fig. 2). The lean construction's detection system is a sensor system to detect the environment inputs which consists of information, labor resources, equipment, technology, etc. According to its own marketing environment (i.e. customer) and macro-environment (i.e. Economic, Legal and Social reasons), the performance system plays the function of transformation and processing, and then outputs the lean construction's services, products and profits. This is a process that the response system acts upon the environment system. The stimulus-response process not only gains the competitive advantages and creates social value for the construction industry, but also achieves the goals of the construction system and its benefit related parties (such as supply chain enterprises).

This is a process that the response system acts upon the environment system.

The aforementioned Koskela' TFV is just an idea. LPDS plans construction projects in the system view, it neglects the environments' affects to the projects and their adaptability.

Therefore, based on stimulus-reresponse model in CAS and lean idea, the paper presents a conceptual model of lean construction which takes into consideration the environment's interaction and effect.

4.2 The Conceptual Model of Lean Construction

Lean production is defined as a flow which contains five steps: defining customer value, defining value stream, building uninterruptible operation flow, pulling

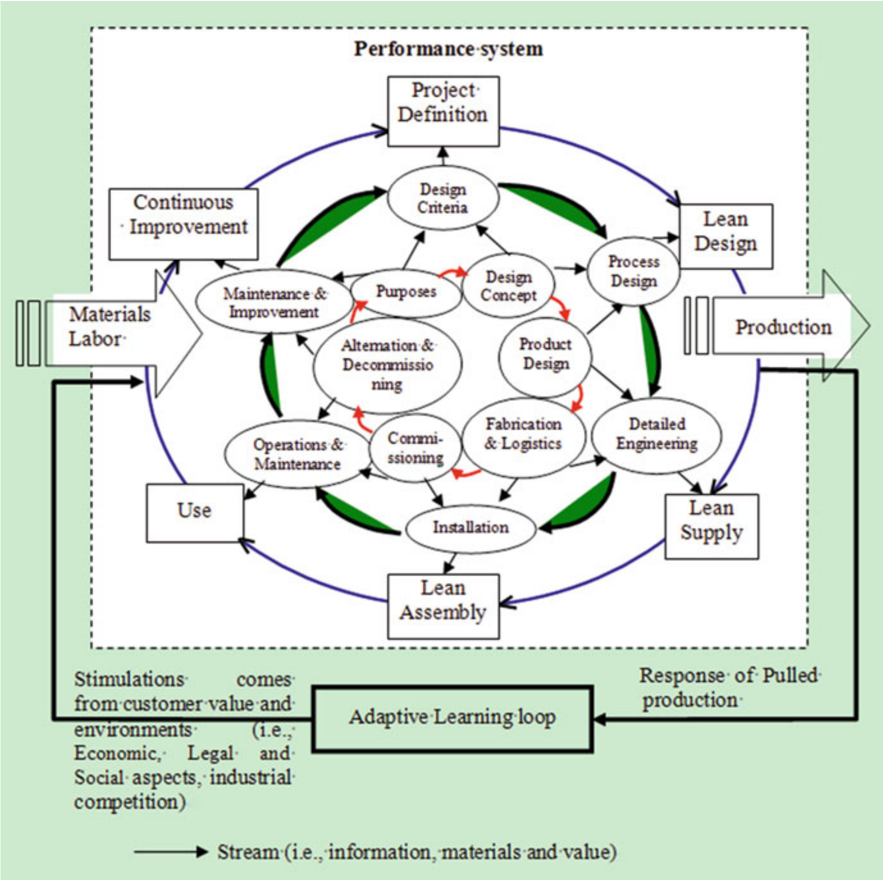

Fig. 3 The conceptual model of lean construction based on CAS theory

production mechanism and perfect. Therefore, the paper pays more attention on the flow concept (involving information, material and value) in the system. Then based on the stimulus-response model of CAS, it treats customer value and environment as the stimulus of lean construction. Its response is the pulling mechanism. The conceptual model of lean construction is formed as shown in Fig. 3.

Firstly, when inputting the materials and labors, at the same time, the model detects the external stimulus from customer value and environments. According to such stimulus, performance system will choose the appropriate translation rules to process then output the products and service to meet the customers' demand.

Translation – Koskela believes that production activity consists of four consecutive processes: moving, waiting, processing and inspection [5, 20]. He categorized all construction production processes into these four stages, and furthermore determined if each stage created value.

The paper argues that the translation of lean construction contains three hierarchies, namely, three cycles. There are three cycle times that can be discussed depending on the level of one's interest similarly. As Fig. 3 shows, Three cycle times include total process level (craft), activity or task level (crew) and subtask or method level (group or individual), and which is from internal to external. The first cycle includes project definition, lean design, lean supply, lean assembly, use and continuous improvement. The second one includes design criteria, process design, detailed engineering, installation, operations & maintenance and maintenance & improvement. The last one includes Design Concept, Product Design, Fabrication & Logistics, Commissioning, Alternation & Decommissioning and Purposes.

Flow – In lean systems, workflow refers to the movement of materials, information, and equipment through a system [6]. Smooth movement, as in better workflow, refers to avoiding the circumstances of continually changing, from being in a state of movement to being stationary.

Value – To optimize the construction production process, non-value adding stages such as moving, waiting and inspection had to be reduced, while the efficiency of the value adding stage was maximized.

However, it was only with the publication of Rethinking Construction (Department of Environment, Transport and the Regions, 1998).

Rule – it absorbs the core idea of lean production. The highest cycle rule of lean construction is as follows:

- The customer's demand is the most important.
- Lean construction pursuits zero waste, zero inventory, zero failures and zero defect;
- To increase project value by transferring tasks with no added value, then to maximize interest and minimize waste.

Adaptive learning loop – Implementation requires a substantial amount of learning. First, learning should be directed at principles, tools and techniques of process improvement. In the next phase, the focus turns to empirical learning from manipulating the processes. For this reason, formal reviews of progress and experiences are useful. One form of learning consists of pilot projects for testing new ideas on a limited scale. A third source of learning is made up by external information, which can be tapped through benchmarking [5].

Lean construction's environment – The lean construction's environment includes the flowing three aspects:

- Economic aspects, both direct (consumption of raw materials, reduction of disposal costs, recovery of the added value of used products, etc.) and indirect (an environmentally friendly image and compliance with current and future legislation).

- Legal aspects, because current legislation in many countries (including, for example, members of the European Union) holds companies responsible for recovering or properly disposing of the construction products they put on the market.
- Social aspects, because society is aware of environmental issues and demands that companies behave more respectfully towards the natural environment, especially with regard to issues like emissions and the generation of waste [21].

5 Conclusions

Integrated with CAS theory, the paper presents a conceptual model of lean construction by referring the related scholars' researches. The model follows the core idea of lean production. It bases on the customer's value and pays attention to value flow and building uninterruptible operation flow, then to study and adapt to environment. However, the shortcoming of the paper only discusses on conceptual model, the practical argumentation is not implemented. This will be improved in the future research work.

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Research on Feature-Based Data Exchange Between Tribon and UG

Wei Liu, Xiong-hui Zhou, and Xue-yu Ruan

Abstract For shipbuilding and auto industry, using different CAD platform to fulfill one project is very popular. Engineers have to deal with so many data exchange works. While the main problem is that many raw modeling features have been lost during this process and could not be inherited by another system. So from this point of view, how to realize the modeling data exchange or called geometry data seamless integration between heterogeneous CAD systems is very important. In this paper, we propose a new method to realize such function. We trace ship hull modeling history in Tribon and then via the XML neutral file, a same 3d model will be regenerated in another system UG. The experiments show that this data exchange method is fairly high efficiency and all modeling features have been inherited. This method can also be widely used in other feature-based CAD platforms such as Solidworks, CADDS5 and CATIA.

Keywords 3d model regeneration • Data exchange • Feature-based modeling • XML

1 Introduction

With the development of computer science, more and more modern CAD systems have the ability to create parametric models. In a parametric model, each entity, such as a line or circle in a wireframe, or an extrude operation, has parameters associated with it. These parameters control the various geometric properties of the entity, such as the length, radius or height of a cylinder. In order to create the desired part, these parameters may be changed by the operator if necessary. Parametric modelers that

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use a history-based method keep a record of how the model was built. When the operator changes parameters in the model and regenerates the part, the program repeats the operations from the history, using the new parameters, to create the new solid [1].

However, different CAD systems have different modeling ways even for the feature definition. A parametric model that was generated in one CAD system will not be recognized or called feature inherited in another CAD platform. In fact, this is very popular in shipbuilding and auto industry [1]. As you know, shipbuilding is an extremely complex business. The time between order and delivery is very short, which means that a huge amount of tasks must be performed in parallel, or in some other cooperation ways [2]. This due to the whole ship model may come from different platform such as Tribon, CADDS5 and UG. How to realize ship data exchange between those heterogeneous systems has become a main problem that engineer have to face. At present, the common way is to use standard file style, such as STEP, IGES that was provided by most CAD systems. While this traditional data exchange method did not took feature parameter and modeling history into account [3]. That means after such exchanging, the original modeling features have been lost and model could not be regenerated in the destination CAD system. To edit or change the model parameters will become impossible.

The objective of this research is to fulfill the data exchange of modeling data of hull between Tribon and UG systems, two important CAD systems in shipbuilding and auto industry, via the XML neutral file.

2 Feature-Based Data Exchanging

By analyzing the modeling framework of Tribon and UG systems, we got to know that the traditional data exchange method by STEP or IGES is useless for feature inherited. Se we define a special neutral file style of our own base on XM. This neutral file can be used to save the ship hull data exported from Tribon. On the other hand, it can be also read by the destination CAD platform after customized development. In this method, any feature-based model can be trace back to its modeling history, so we can realize data exchanging process by rebuilding modeling history tree in different CAD system.

2.1 Frame Structure

Feature-based data exchanging aims at feature information sharing between different CAD systems. The whole exchanging process can be divided into two parts as shown as follows Fig. 1.

There are two steps for this exchanging process. One is pre-processor and another is post-processor. Pre-processor mainly used to read modeling data from local system as far as Tribon is concerned. During this process, these extracted data will

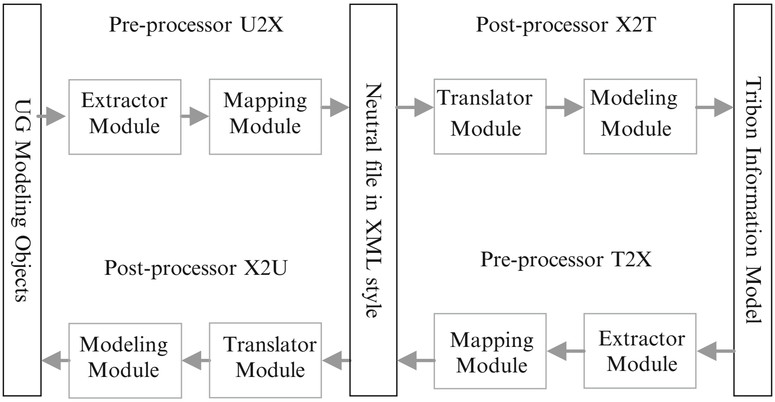

Fig. 1 Feature-based data exchanging framework

be organized according to a mapping module and then exported in a neutral XML file. By contraries, post-processor mainly used to translate these neutral files and fulfill the model regeneration in the target system.

2.2 *Development Tool*

Like many modern CAD systems, Tribon provide user a built-in programming tool Vitesse [1]. Tribon Vitesse is a productive way to create customized, user-developed macros or programs in an object-oriented language. These macros are then available within the interactive Tribon application through a special function on the menu. A customized interface that we developed by this tool can be shown as follows Fig. 2.

Tribon Vitesse incorporates the programming language Python [1]. This syntax includes all normal features in a programming language such as branching, loops, functions, etc., as well as full support for the object-oriented programming. The Python language itself gives the use the full freedom to work in a traditional function-oriented fashion. Its implementation in Vitesse, however, requires the programmer to gain also the basic skills in the object–oriented approach, because the Tribon entities and activities have been modeled in the Python language as classes as its methods.

By calling the corresponding utility functions that was encapsulated by Vitesse, the programmer can easy access Tribon product information model and its database.

2.3 *Ship Hull Exchanging Objects*

Tribon product information model can be regarded as a ship database containing all information about a specific project. The database is object-oriented in the sense

Fig. 2 Screenshot of the T2U client developed by Tribon Vitesse tool

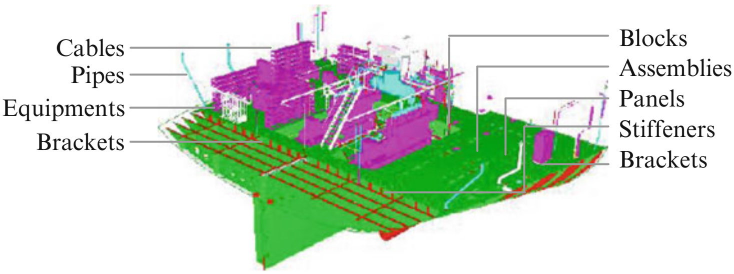

Fig. 3 Ship hull and outfitting topological structure

that all design and production data is stored as "objects". These "objects" are all the types of physical items found in shipbuilding, e.g. [4] (Fig. 3).

There is a hierarchy within the product information model, which helps the user keep track of the information and produces production information more efficiently [5]. An example of this hierarchy is shown in the following diagram.

2.4 XML Neutral Files

Extensible Markup Language (XML) is a markup language that defines a set of rules for encoding documents in a certain tag format that is both human-readable and machine-readable. It is a data format used extensively to describe structured data [6].

Table 1 A glance at XML neutral file for ship hull

Keywords (Class1, Class2, Class3, Class4, Class5)	Feature
Ship Hull Block Panel Tran matrix	
<Ship name="dc_18000">	Seam
<hull>	
<block name="SP505" id="1">	Contour
<panel name="SP505-41" id="1">	Notch
<tran_matrix>[0, 3, 0,1,0...]</tran_matrix>	
<main_plate>	Hole
<thickness>20.0</thickness>	Cutout
<nseg>4</nseg>	
<seg id="1">	Bracket
<start_point>5,1,0</start_point>	Flange
<end_point>5,1,0</end_point>	
<amplititude>0,0</amplititude>	Pillar
</seg>	
</main_plate>	Stiffener
</panel>	Plate
</block>	
</hull>	Sub panel
</Ship>	

Since the XML documents are standard test files, it is virtually possible to handle them, using standard Python abilities of handling files. This becomes, however extremely difficult with the growing complexity of the document [7]. Therefore, we have to develop a translation module to facilitate the handling of the XML. For example, we can use the following code to obtain an existing XML document in TRIBON development circumstance [8].

From xml.dom.minidom import parse

```
try:
     doc=parse("D:\\test.xml") #Build XML document
try:
              ... #Work on the document
     finally:
              doc.unlink() #Prepare for cleanup
except:
     kcs_ui.message_confirm("Error reading file!") [1]
```

In this paper, we use a kind of XML neutral file to record ship hull modeling history data. These neutral files are composed by some well-regulated macro unites [9]. In this method, Modeling data are described by modeling macro (modeling history tree) instead of geometry element, such as point, line and surface. Macros unite is a data structure with two-dimensional characteristic. Each macro unites will give expression to a certain hull structure: parallel unites describe the structure that lies in the same class, while longitudinal unites describe the structure that lies in different class [10]. We put the ship hull data into five classes: Ship, Hull, Block, Panel, Tran matrix. This can be shown in the following Table 1.

2.5 Co-ordinate Translation

In the ship hull creation process, we adopt a variety of positioning ways. For example, we work with three kinds of co-ordinate systems in Tribon platform. Drawing co-ordinate system will be used under screech circumstance, global co-ordinate system and panel co-ordinate system will be used when we need to create a solid feature [11]. The coordinate variables shown as follows:

- drawing co-ordinate system (U, V)
- global co-ordinate system (X, Y, Z)
- panel co-ordinate system (U, V, W)

In addition, Tribon and UG NX differ from the definition of the relative coordinate system. So, during the model regeneration process in the destination platform UN NX, we have to deal with the co-ordinate translation problems. If the coordinate transformation is linear, we need to change source coordinates from (x, y) to a new pair of coordinates (x′, y′). The conversion express can be written as a matrix equation. The most general linear coordinate transformation of R^2 has the following form:

$$\begin{aligned} x' &= \mathrm{a}x + \mathrm{b}y \\ y' &= \mathrm{c}x + \mathrm{d}y \end{aligned} \tag{1}$$

Where a, b, c, and d are real-valued constants with $\mathrm{ad} - \mathrm{bc} \neq 0$. Now we can easily see that this transformation may be expressed as a matrix equation as follows:

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \mathrm{a} & \mathrm{b} \\ \mathrm{c} & \mathrm{d} \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} \tag{2}$$

What if we want to return to the old coordinates? Then we apply the inverse coordinate transformation, given by:

$$\begin{bmatrix} x \\ y \end{bmatrix} = (\mathrm{ad} - \mathrm{bc})^{-1} \begin{bmatrix} \mathrm{d} & -\mathrm{b} \\ -\mathrm{c} & \mathrm{a} \end{bmatrix} \begin{bmatrix} x' \\ y' \end{bmatrix} \tag{3}$$

These equations may be written symbolically as $\mathrm{x}' = \mathrm{Ax}$ and $\mathrm{x} = \mathrm{A}^{-1}\mathrm{x}'$. It is easy to see that the first of these equations implies the second; just multiply both sides on the left by A^{-1}. When written out as a system of linear equations, the above matrix equation becomes:

$$\begin{aligned} \mathrm{x} &= \left(\mathrm{dx}' - \mathrm{by}'\right) / (\mathrm{ad} - \mathrm{bc}) \\ \mathrm{y} &= \left(-\mathrm{cx}' + \mathrm{ay}'\right) / (\mathrm{ad} - \mathrm{bc}) \end{aligned} \tag{4}$$

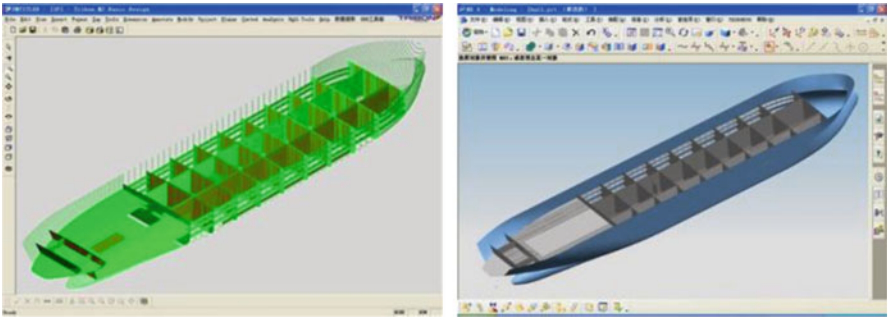

Fig. 4 Comparison for Tribon hull model and regenerated model in NX

2.6 Application Examples

In this paper, we use the programming language Python which has been integrated within Tribon as the customized development tools. The syntax includes all normal features in a programming language such as branching, loops, functions, etc., as well as full support for the object-oriented programming [12].

Within the research project, two customized clients are implemented as prototypes. These are used for demonstration and special design purposes. Both are implemented in Python. T2U client is used for visualization and to generate the user interface of hull data export [13] (Fig. 4).

For the usage in hull structural design, this client is integrated into the Tribon hull-drafting module using the Vitesse application-programming framework. This client program is used as named, i.e. [14]. It provides an interface or called tools to the knowledge based design and related information stored in the standards database. Basic workflows like the standards conformant construction of brackets and cutouts are implemented. For a design task like the definition of a bracket attribute values are entered automatically as far as possible thus reducing the number of user inputs required [15].

Due to the open design and the consolidation of the complete application logic into the server the development of additional clients that integrate CAD–systems or further applications into the system is possible [16].

3 Discussion

In this paper, we talk about the possibility for feature-based geometry data seamless integration between heterogeneous CAD systems. The author trace ship hull modeling history in Tribon and via the XML neutral file, a same 3d model has been regenerated in another system UG. In case of ship industry, this method was proved to be effective.

Currently, the data exchange method apply is a first prototype focused on design, storage and retrieval of standardized parts. It is a highly configurable and flexible system. By using the data model described, engineers have a unique data source for the steel structural design process. The access to additional information using entity information derived classes allows for a further consolidation and a tighter integration of all relevant pieces of information [17]. Further work is currently carried out on the closer integration of a 12 rule–based computation system for the dynamic evaluation of parameters or conditions. Advanced workflows for a guided wizard-based design are developed.

4 Conclusion

By feature-based data exchanging method, a ship hull model has been regenerated successfully in UG. The experiments show that this data exchange method is fairly high efficiency and all modeling features have been inherited in the destination system. This method can also be widely used in other feature-based CAD platforms such as Solidworks, CADDS5 and CATIA [18].

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Construction of System Framework of the Most Stringent Water Resources Management Regime

Ju-ling Qiao and Fang Liu

Abstract Innovation of water resources management regime is an inevitable choice for economic and social development. It would be beneficial to sustainable development of the harmonious society between human and water as well as to sustainable utilization of water resources if the connotation of the new-type water resources management regime could be defined, the institutional system be established, realization approaches to be discussed, and the limited water resources could be used to the full extent both in development of economy and society and in virtuous cycle of ecological environment.

Keywords Realization approach • The most stringent management regime • Water resources

1 Introduction

Water scarcity has already become the key bottleneck restricting economic and social development, and meanwhile, water resources will turn to be badly needed. People of our times are faced with a significant and urgent topic, i.e. how to develop and use water resources to meet human needs while water resources could be managed and protected for sustainable utilization. This requires us to summarize and analyze successful water resources management experiences in

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domestic and overseas practical explorations, to discuss a new type of water resources management system, so that the harmonious coexistence between human and water could be finally achieved.

2 Connotation and System of the Most Stringent Water Resources Management Regime

2.1 The Concept of Water Resources Management

As for the concept of water resources management, although this term has been extensively applied, up to now, there has been no uniform and normative explanation in the academic world. Water resources management is defined in "Wikipedia-English" as follows: "water resources management refers to organization, coordination, supervision and scheduling of development and utilization of water resources; through administrative, legal, economic, technical and educational approaches, all kinds of social powers are organized for water conservancy development and of control water disaster; social and economic development is coordinated with development and utilization of water resources, while conflicts in water utilization is handled among each region or each social department; inappropriate development and harms of water resources are monitored and restricted; the scheduling program for optimization of water system and reservoir engineering is established for scientific allocation of water" [1]. Water resources management has a wide coverage in broad sense, thereby all tasks for water conservancy being carried out in nowadays could completely incorporated into water resources management. At present, a relatively universal definition for water resources management is that: the departments of water administration manage the development, utilization, scheduling, allocation, conservation and protection of water resources through legal, administrative, economic and technical means etc., which is the general term for all kinds of engineering and non-engineering measures meeting needs for human survival and living, social and economic development, as well as maintenance and improvement of ecological environment [2].

2.2 The Connotation of the Most Stringent Water Resources Management Regime

In 2011, a new type of water resources management regime was clearly put forward in the No.1 Central Documents and in the Central Water Conservancy Working Conference, which was also the ever strict ever regime on water resources management, being positioned as the "strategic move for speeding up transforming ways of economic development". It was not only a remarkable breakthrough in the history of water resources management, but also an innovation in water resources management regime, symbolizing a new leap in our knowledge in the law of water control and even of sustainable development. The most strict regime has already become the core for modern water conservancy management regime, whose connotation could be summarized as "establishment of three red lines and four regimes", i.e. through establishment of the red line for controlling of water development and utilization, the control regime for water utilization volume could then be set up; through establishment of the red line for water utilization efficiency, the control system regime for water utilization efficiency could be set up; through establishment of the red line for total quantity of pollutant discharge into rivers and lakes, the regime for restricting permissible pollutants in water function zones could be set up; through establishment of the regime of management responsibility and appraisal, the institutional system for water resources management could be supported and improved.

2.3 The System of the Most Stringent Water Resources Management Regime

The general framework of the most stringent water management system is composed of six major systems, i.e. water conservancy engineering system, control indicator system, supervision and administration system, scientific monitoring system, indicator assessment system and management organization system.

2.3.1 Water Conservancy Engineering System

As the supporting foundation for implementation of the most strict water resources management regime, it is composed of water source engineering, water network engineering and water supply engineering, etc. Without perfect matching water conservancy facilities for water storage, diversion and transfer, the most strict water resources management regime would lose its root. Through water source engineering, natural precipitation could be dammed up and underground water be exploited out, so that natural water sources are turned into potential water resources available for human beings; through water network engineering, river and lake water systems in different basins and in different areas could be connected, so that the potential water resources are transferred and allocated to each region; through water supply engineering, water could ultimately be supplied to each industry and each family, so that the potential water resources are truly converted for direct utilization [3].

2.3.2 Control Indicator System

It contains three control indicators respectively for total water consumption, water use efficiency and water function zone restriction, which could be seen as the criteria measuring execution of a set of regimes. Establishment and improvement of a systematic and complete control indicator system is the basic premise for implementation of the most strict water resources management regime, which should be broken down and put into practice in response to control indicators for total water consumption, water use efficiency and water function zone restriction, etc. (i.e. known as the "three red lines"). The "three red lines" constitute an organic integrity with internal logistics under mutual support and correlation, fully representing the philosophy that equal attention should be paid to allocation, conservation and protection. Meanwhile, we have established the management mechanism for water resources development and protection warning, and have successively created, printed and distributed the "three warning lines" for available water supply for key water conservancy projects, ground water level of key underground water sources and pollutant carrying capacity of key water function zones [4].

2.3.3 Supervision and Administration System

It includes maintaining a strict standard respectively on certification and permission, water utilization planning and metering and charging. Enhancement of supervision and administration of water taking and utilization could be regarded as the most important handle for our water conservancy departments when they are striving to put the most strict water resources management regime into practice. Only if this handle is firmly held, could water consumption of a region be really controlled and could the most strict water resources management regime be really implemented. This can be seen as one of the functions best representing administrative authority of our water conservancy departments. In terms of specific assignments, there are "three gateways" requiring strict control [5].

2.3.4 Scientific Monitoring System

It contains the monitoring system for regional total water consumption, real-time monitoring system of key water users and the water quality monitoring system of water function zones. As for the most strict water resources management regime, approval of each control indicators as well as monitoring and appraisal of regime implementation require huge amount of monitoring data as support. Therefore, to speed up constructing and improving a scientific and complete monitoring system turns to be an important foundation for implementation of the most strict water resources management regime [6]. Starting with the actual demand in implementation of the most strict water resources management regime, the present situation urgently requires construction and improvement of monitoring systems for these three aspects.

2.3.5 Indicator Assessment System

It involves assessment of total regional water consumption, control indicator for water efficiency and control indicator for pollutant carrying limit. A key link in implementation of the most strict water resources management regime lies in that to establish the assessment system of control indicators, compare the monitored actual regional water consumption with control indicators stated in the "three red lines", make assessment with scientific and object method, point out achievements and problems and finally acquire reasonable assessment conclusion and opinions [7]. Such assessment aims at formulating reasonable control indicators for regional water consumption in the next year or in the zone under planning, as well as providing important reference for appraisal of each level of local governments and relevant departments. Such assessment mainly focuses on total regional water consumption, water efficiency and pollutant carrying control of water function zones, and relevant procedures include reliability analysis of original monitored data, data verification and comparison, error analysis, comparison of actual monitored data and control indicators, reason analysis, comments and suggestions, etc. The institution for assessment could be the assessment specialist group established by water administrative authority or a consulting agency, and the assessment conclusion should be timely released to the public [8].

2.3.6 Management Organization System

This system includes formation of a centralized and unified water resources management regime, a coordinated management system and a professional service system in water resources management. A healthy and complete water resources management organization plays the role of effective support to efficient functioning of the most strict water resources management regime. During implementation of such as regime, only if a reasonable and effective management regime, management system and service system come into being, could we see the effect of the most strict water resources management regime.

3 Realization Approach of the Most Stringent Water Resources Management Regime

It is completely a new task as well as a long-term and tough mission to implement the new-type water resources management regime, i.e. the most strict water resources management regime. The promotion process is surely to be filled with difficulties and challenges, upon which we should be fully prepare to develop the spirit of conquering hardships and bold for tough battles. We should explore and innovate bravely, while going ahead steadily and surely for practicality and efficiency. To guarantee effective implementation of the most strict water resources management regime, the following three aspects should be emphasized.

3.1 Enhance Publicity, to Improve Awareness of the Whole Society

Implementation of the most strict water resources management regime involves all walks of life and all fields and running through each level such as the nation, region and user, etc., requiring joint efforts of the whole society for support and promotion. Therefore, it is necessary to further enhance direction of public opinions through all kinds of channels, vigorously develop publicity and education of the most strict water resources management regime and deepen awareness and acknowledgement of the whole society of such a regime. First, education of water regimen should be strengthened. It should be incorporated into national education system and educational program for primary and middle schools as well as training courses against leading cadres at each level and civil servants. Compilation and printing of relevant teaching materials should be well controlled. The government shall plan jointly with educational departments for construction of practice bases for water conservation education, to promote water regimen education into school, classroom, community and family. Second, promotion and guidance of public opinions should be enhanced. Popularization of water regimen should be strengthened. Water conservancy should be incorporated into public welfare publicity, to improve the whole society's consciousness of water crisis, water conservation and water resource protection, so that water cherishing, conservation and protection will become conscious action of all citizens and become an important criteria measuring civilization degree of the whole society, resulting in the healthy social atmosphere in which "honor to saving water, shame to wasting water". Third, guidance of demonstration by example should be well managed. The motivation mechanism encouraging advanced workers and first to excellence. Demonstration county (city/district) establishment for standardization construction of the most strict water resources management regime should be organized and developed in which counties (city/district) working ahead and creating experience would be nominated to be honored, so as to stimulate overall promotion of implementation of the most strict water resources management regime [9]. On the basis that construction of national/provincial demonstration city/county for the water conserving society is well controlled, selection, nomination and commendation of water-conserving demonstration county/town, district and unit should be organized and developed, so as to guide construction of the water-conserving society onto the path of continuous deepening promotion.

3.2 Strengthen Appraisal, to Improve Attention of leaders at Each Level

Appraisal is divided into three levels: first, to strengthen appraisal of implementation of the "three red lines". Control indicators of the "three red lines" i.e. total water consumption, water efficiency and water function zones restriction, should be incorporated into comprehensive performance appraisal system of local scientific development, which is under responsibility of local administrative leaders. Effect of water conservancy reform and development including implementation of the most strict water resources management regime should be incorporated into comprehensive appraisal system of annual scientific development of each region, the weight of which would be obviously improved. Water conservancy reform effect of each region should be appraised by water administrative authorities altogether with related departments, and the appraisal result would be submitted to the authorities of leaders, which then becomes important content measuring scientific development of a region, as well as significant basis for comprehensive appraisal and evaluation of relevant local leaders and cadres. Any performance breaking through the "three red lines" could be vetoed by one vote. For situations that control of total water consumption is not strict enough, licensing approval of water taking is administratively interfered, or severe problems occur in water supply, relevant leaders and responsible people would be strictly called to account. Second, to strengthen internal appraisal of the system. According to detailed implementation measures for supervision and appraisal of water conservancy missions with annual significance, implementation of the most strict water resources management regime is considered as the content of weight, which accounts for 20 points in the overall a 100 mark appraisal system. Each water administrative authority should also strengthen appraisal and evaluation of implementation of counties (district/city) within jurisdiction. Third, to strengthen the appraisal of water users. Water consumption planning and management should be strictly implemented upon water users. The appraisal and incentive mechanism for water efficiency should be established, water efficiency indicators being incorporated into statistical indicators of enterprise business benefits.

3.3 Strengthen Law Enforcement, to Improve Acceptance Degree of People Subject to Administration

Implementation of the most strict water resources management regime is mandatory in a lot of aspects, which belongs to the scope of rigid management. Without powerful supervision upon law enforcement as a significant guaranty, this regime would be impossible to be really put into practice. So we should start from water management according to law. Firstly, we should strengthen management of water resources. While further improving legal system construction in water resource management, the greatest importance in water administrative enforcement should be attached to supervision of water consumption behaviors. We shall enhance construction of the professional water administrative team, equip it with stronger legal enforcement power, intensify fund guaranty and improve level of legal enforcement equipment, so as to build a water conservancy enforcement team from the bottom to top, being qualified as "highly disciplined, well equipped, with regulated enforcement and quick response". We shall seriously put the water-drawing permit system into practice, and strictly follow the approval and execution of duties regulated in the "Regulation on the Administration of the License for Water Drawing and the Levy of Water Resource Fees" issued by the State Council. As for any examination and approval beyond authority, the duty of supervision and administration would be strictly performed, which would be corrected or revoked according to law, and relevant departments and staff would be strictly accounted. Secondly, we should innovate the law enforcement mechanism in water resource management. Water resource management involves multiple social aspects and departments; thereby we shall be good at sailing a boat by water and sailing by wind in integrating social law enforcement resources. A frequent work connection and coordination mechanism should be built up with departments such as public security, court, governmental legislation, land, construction and environmental protection, etc., aiming at acquiring their powerful support and cooperation to create joint efforts in water governance and administration according to law. We should continue to powerfully promote water policing system. With integration of local realities, construction of joint water and public security enforcement institutions e.g. water police station and water security office, etc. should be accelerated [10]. Thirdly, we should strictly regulate law enforcement behaviors. To define responsibilities of law executors should be the first mission. Water administrative executors at each level could only perform within their scope of their duties and functions, thus any actions beyond the scope would be considered invalid. During enforcement process of water resource assessment and examination, water-drawing permit approval, and levy of water resource fees, etc., water administrative authorities at each level should have clear sense of responsibility and implement their own duties in real earnest.

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Research on the Integration Mechanism and Strategy of the Services Innovation and the Manufacturing Industry

Xin Zhu

Abstract The goal of this paper is to analyze the integration mechanism and development strategy of the services innovation and the manufacturing industry. Firstly, we make an introduction about the connation of service innovation with the four dimensions model. Secondly, we make an analysis about the need and impact for the use of services innovation in the manufacturing industry. Then, we make a discussion about integration mechanism of the services innovation and the manufacturing industry. Finally, we put forward the strategy for the integration of services innovation and the manufacturing industry, which can guide their further integration in the near future.

Keywords Integration mechanism • Manufacturing industry • Strategy • Services innovation

1 Introduction

With the rapid economic development in the world, the important role of the service sector in economic growth has become a significant feature in the advanced economies. The proportion of value added services accounted for the increase in the world total production value is an average of 68 %, the proportion of service sector employment in developed countries are generally about 70 %. With the deepening of international division of labor, the increasing demand for services, increased competition in services and some industry barriers to entry reduce the

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service sector assumes an international, standardized and customized development trend of science and technology development, social progress and economic growth and so play an important role.

The rapid development of science and technology of China's economy in recent years has improved continuously rising, the social hierarchy of needs, people's consumption structure began to change, these changes are put forward higher requirements for China's service industry development and innovation. China achieved rapid development of services since the 1980s, but for the service industry in the Chinese domestic market demand, the current situation and the needs of economic development remains to be further improved and optimized. Service innovation is an important driving force for the services sustained and rapid development, international research on service innovation began in the 1970s, has important implications for the promotion of the service industry's rapid development and economic prosperity [1]. Therefore, research and service innovation and its effect on the service of economic growth in the role of promoting China's service industry rapid development, and thus meet the economic development needs of social progress, structural change and market demand has a positive significance.

2 The Connation of Service Innovation

For a long time, the service sector is considered a "non-material production" remaining sector, is seen as an appendage of the manufacturing sector, characterized by: less demanding professional, staff-intensive and low capital investment, less innovation activities and efficient but innovation in the service industry does exist, each of us have experienced, when we travel by air, eating at fast food restaurants or use the loan to buy a car, etc., will experience the benefits of service innovation. Innovation and its meaning is very broad, Schumpeterian, Austrian-American economist treated that innovation is all possible to improve the efficiency of resource allocation activities; these activities are not necessarily technology-related.

Innovation is not a tangible product, invisible, is a conceptual, process innovation activities; services to innovative forms of diversity, technological innovation is just one of a dimension; innovative range of service innovation compared with wide, and is replicable innovation and solve specific customer problems can not be copied innovative complex; "customer oriented" service innovation, innovation is more a demand-driven phenomenon, the customer as a "cooperative producers "active participation throughout the process of innovation; less service innovation more for the enterprise level, industry level of innovation. "Invisible" in the above five elements, the core elements of the other four elements are based on some degree of derivative, between the different elements are interrelated with each other. The four dimensions are the new concept, customer interface, the delivery system and technology option, associate and interact between the different dimensions, corresponding to the different functional activities.

2.1 Dimension of New Services Concept

In manufacturing innovative products and processes are visible, but in the service industry, innovation is mostly intangible, innovative results is not a tangible physical products, but new concepts or methods to solve a problem, service innovation to a large extent is a conceptualization of innovation. Even if a concept in other markets, customers are familiar with, but on a particular market is an innovation. Of course, not all service innovation should be to introduce new concepts, accounts for a sizeable proportion of the conceptualization of innovation in service enterprises. Services companies during the development of new service concepts, the need to clearly answer some basic questions: what products to retain existing customers and develop new customers? What is the product of competitors? How the new service delivery to the actual customers and potential customers? These issues constitute the scope of the new service concept. Obviously the concept of innovation in this sense is a market-driven enterprise by scanning and analysis of market demand to find innovative sources [2]. The new service concept dimension has an accurate understanding of their existing services and new services, as well as competitors, existing services and new services, in particular, have an accurate grasp of the innovative features. Through the understanding of the new service concept, service companies can continue to market changes, customer requirements and behavior of competitors to develop new services and improve existing service, the formation of the enterprise "business intelligence". Service and innovative new service concept dimension with the other three dimensions are closely related. The concept of innovation or new technological opportunities, or from new production process, there may come from customers in the new role of service provider.

2.2 Dimension of Customer Interface

The second dimension of the service innovation is the customer interface design, including the service provider to the customer and communicates with their client cooperation [3]. For the analysis of the customer interface has become a focus of the current service innovation, but for mass production manufacturing innovative research, scholars have usually ignored the interactions between customers and providers and enterprises will be included in the innovation process. Customers to a large extent have become an indispensable part of service production, especially for the ultimate customer service. Service providers with customer communication and interaction have become a major source of innovation. Those services do not have the obvious physical characteristics or likely to be competitors, product substitution, the interface between service providers and customers is more important, more needs to service providers to invest in building relations with customers, and continue to develop new customer interaction mode. This innovative first condition is a lot of information to actual and potential users. Service enterprises in the design of the customer interface must take into account the following basic questions:

how to effectively communicate with customers? Who the potential customers? Enterprises have the ability to allow customers to play the role of “producer” in the innovation? To the above questions the correct answer is the basis and premise of the service enterprises to establish a good customer interface.

2.3 Dimension of Service Delivery System

The dimension of the service delivery system refers to the organization of production and delivery of new service products [4]. Internal organizational arrangements, the dimensions focus on service enterprises through appropriate organizational arrangements, management and coordination, to ensure that employees work effectively and to develop and deliver innovative service offerings. Closely related to the dimensions of the problem is: How to authorized employees? How to motivate employees to complete their work and pass the new service products? Dimension of the service delivery system is the core of emphasis on the ability of the existing organizational structure as well as existing staff must adapt the needs of the development of new services, such as not suited to, it is necessary to upgrade to promote innovation through the design of the new organization structure and staff capacity, training, carried out smoothly. Obviously, the dimensions of the service delivery system and customer interface dimension has a close association, the internal organization and delivery mode (the service delivery system dimensions) with the interaction between employees and customers can not be separated, and the two are intertwined and mutually supportive. The most obvious example is the introduction of e-commerce requires a larger business process reengineering business processes. It not only changed the way of actual commercial transactions, but also changed the process before and after the transaction; the enterprise’s internal organization and the competency of staff must change. Again, the large scale introduction of home shopping service to the association of service providers and customers to a dramatic change, but also to make the organizational structure and staff skills also changes greatly. It should be noted that the dimension of the service delivery system, the organization of employees authorized is particularly important, especially in professional services (such as advertising services, computer services, design services, etc.). Through the proper authorization to provide staff with greater flexibility, improve the efficiency of innovation to ensure that innovation successfully is very useful.

2.4 Dimension of Technology Option

Service innovation can be no technical involvement, so the technology is not a necessary dimension of service innovation in the model is only an optional dimension. Although not necessary dimensions, but the technology is still in service innovation plays an important role, “technology” and “service innovation” there are a wide range of relationships, most of the services through the use of certain technologies become more efficient, such as the use of ICT (information and communication technologies), the use of the shopping cart in the supermarket, the use of the storage system. There are many sector-specific technologies in service innovation, such as cleaning and monitoring system technology in medical technology in the health services, environmental services, public catering and hotel services, food and cooking techniques, retail services and goods transport refrigeration and temperature control technology. These technologies will have a major impact on the specific service sector. Of course, certain technologies can be in many service sectors is widely used, ICT is an obvious example. ICT could be carried out in the vast majority of service sector with a lot of information processing, so it becomes a kind of almost all economic activities are the internal need of technology. Scholars have often felt that ICT is a huge driver of service innovation, the typical supplier-led "innovation point of view, one of the most influential is the Barras (1986) put forward the" reverse product cycle "theory. The theory is that innovation in the services sector is formed due to the absorption and use of IT. However, the service is not always "supplier-oriented, many service companies in the process of introducing the technology (equipment) and process the conduct of other innovative activities, and further caused by the customer and market innovation in service enterprises are more prevalent and important.

3 The Need for Service Innovation Used in the Manufacturing Sector

Today, the world has entered a post-industrial society as represented by the service economy, the consumer market key link, the service has become an important factor of the core competitiveness of enterprises, service innovation become an independent and innovative activities, is becoming increasingly important in the development of the manufacturing industry. Enterprises can consolidate and expand the market by service innovation, competitive differentiation and advantage. This competitive advantage generated by the service innovation in products, marketing, network, organizational resilience, brand and corporate competitiveness [5].

As for products, the production of traditional manufacturing enterprises pay more attention to internal production rather than the reaction of the target, too popularization of products on the market unresponsive; application services and innovative manufacturing enterprises were concerned about the fast changing market needs, with customer interaction, to grasp the hot market, design and production of diversified products, targeted to achieve good returns.

As for marketing network, the traditional corporate enterprise boundaries, the vast majority of departments and clients (customers) in isolation, only through the narrow channels of the sales department and market to establish a one-way links, not only fail to timely customer information is passed to the enterprise, nor can the results of the final processing of the information fed back to the source of information (such as customers); application services and innovative manufacturing enterprises in the internal market between the established multi-channel closed-loop network, market interaction, and all information processing results can eventually be fed back to the source of information to retain and explore clients' assets to provide channel protection.

As for resilience in the organization, the traditional focus on the stability of the organizational structure and hierarchy, through the establishment of a rigid organization and the introduction of fixed processes to deal with management problems, the results of anti-enterprise inefficiency, poor resilience; and application of innovative manufacturing enterprises for their internal and external clients, the establishment of flexible flat network organization to cope with new problems that may arise at any time.

As for the brand, more than the evaluation of the product of the traditional enterprise from their own point of view, and only focus on product cost rather than the customer's perceived value, customer satisfaction is not high, the reputation of the brand is also very low; and application services and innovative manufacturing enterprises from the clients point of view, to provide customers with satisfaction with the product, easy to form the brand reputation and customer loyalty. Various advantages, the overall competitiveness of the application of innovative manufacturing enterprises than traditional enterprise, its products are difficult to imitate, not only leading the industry's opponents, but also raise barriers to entry, reducing the potential competitors and substitutes the threat.

4 The Impact of Service Innovation in the Manufacturing Sector

Between service and manufacturing a wide range of interaction, the development of many services sectors are dependent on manufacturing, these sectors for the manufacturing, finance, advertising, marketing, consulting, communications and other services to support development; the same the healthy development of the manufacturing sector is also dependent on the service sector, manufacturing product quality and enhance the competitiveness depends on the integration and effective use of the various service elements, this effect is mainly manifested in:

1. Service technology improves the response time in the manufacturing sector. The success of the manufacturing sector need to have a more rapid response, more customers and a shorter cycle, all of which rely on integration services and related services technology, effective use, such as marketing, technology, advertising technology.
2. Service has become an important source of manufacturing competitiveness and profits [6]. Some manufacturers of large-scale sales and support systems for the enterprise to provide more opportunities for development, many equipment manufacturers by providing training services for enterprise customers for more profit in selling equipment, and IBM have long attention to software, networking,

and communications connectivity, these services are an important source of manufacturing value-added and profit of enterprise value, and service elements is becoming a key competitive weapon for large-scale manufacturing enterprises.

3. Services reduce costs while increasing product value. Modern manufacturing, the contribution of basic commodities, the value is often less than the value added by a variety of internal and external services in the enterprise, manufacturing enterprises 75 % of the cost and a higher proportion of the value increase by service activities constitute therefore a reasonable choice and use of services will reduce costs, increase value to their products.
4. Manufacturers benefit from the external service innovation. Service enterprises has become an important innovator, greatly improved the quality, scope and flexibility of service delivery, resulting in a number of innovative new products, customers (including manufacturers) can benefit in the competitiveness of enterprises in the service.
5. The services support the activities of the manufacturer's international operations [7]. Services technology impact of manufacturing the most significant area is in the manufacturing sector, international operations, multinational manufacturing company to obtain economies of scale in large part by its service capabilities (enterprises in technology transfer, marketing, finance, logistics, etc. ability) to obtain, rather than from manufacturing economies of scale.

5 The Intergration Mechanism of Services Innovation and Manufacturing Industry

The relationship between services and manufacturing are becoming more and more closely, mainly in the manufacturing sector, intermediate inputs invested in the service to a substantial increase in activities external of the manufacturing enterprises has also led to the development of emerging services sector, which gave birth to the service the integration and development of industry and manufacturing. Industry integration can enhance the competitiveness of the industry chain, to achieve the coordinated development of various industries [8]. In the current economic development, the integration between modern manufacturing and service development more performance the penetration of the service sector to manufacturing, production services related to the production process, a direct role in the manufacturing production process. The development of the blend is mainly reflected in three aspects:

5.1 Within the Enterprise Industry Fusion Development

At present, many companies manufacturing and service functions together, operations management from the manufacturing sector extends to the service areas, some of the economic activities of enterprises and even by the manufacturing center to service center. In many famous multinational companies in the service sector share of output value and profits higher and higher, it is difficult to determine whether it is a manufacturing business or service enterprises. For example, the U.S. General Electric Company service penetration into their daily operations management, manufacturing capabilities to the service function of conversion, through GE Capital, the world's largest financial companies to develop financial industry, has greatly enhanced the market competitiveness. At present, services revenue has accounted for more than 2/3 of the total revenue of the General Electric Company.

5.2 *Industrial Chain Integration and Development of Manufacturing and Service Innovation*

A product in real time of production and manufacturing sector accounts for only a small part, most of the time in research and development, procurement, storage, operations, sales, service and other stage of the operation of the industrial chain to rely more on producer services, the efficiency of the service sector a great influence on the efficiency of the entire chain.

5.3 *Regional Integration Within the Development*

That means manufacturing and service industries in a specific geographical cluster. At present, China has entered a stage of industrial clusters and industrial competitiveness are closely associated. Pearl River Delta, Yangtze River Delta and other regions have demonstrated the phenomenon of industrial clusters. Finance, insurance, logistics, education, training and production services and manufacturing, constitute the industrial clusters of the service support system, and promote the healthy development of industrial clusters.

6 The Strategy for the Intergration of Services Innovation and Manufacturing Industry

From the perspective of innovation systems analysis, service innovation systems and manufacturing innovation system, both may be integrated in the future. First of all, service innovation in the capital, technology and other aspects of low-cost advantage makes it easy to adopt means of competition; Second, the heterogeneity of service innovation it has a strong "personalized", businesses can be enhanced through innovative products unique and distinguish it from competitors; again, the value-added services, often bigger than the product itself, the added value of enterprises will get more added value through service innovation; Finally, the service innovation in the reputation, safety, speed, etc. aspects will also bring a stronger competitive edge, and make it easier to win a larger group of customers in the marketplace, and to some extent, reduce the risk of innovation in other areas such as technological innovation.

6.1 The Strategy for the Integration of Services Innovation and the Manufacturing Enterprises

Many manufacturing companies have innovation as an important differentiation strategy, hoping to meet the individual needs of customers and markets to a greater extent, and "production business" to the "Service". The service innovation and manufacturing innovation system interact and integrate with each other gradually [9]. Manufacturing focus of competition has been gradually shift from tangible to intangible, the shift from a rigid flexible service innovation strategy, product features, marketing, network, organizational resilience, brand and corporate competitiveness has certain advantages, and will make use of differentiation competitive advantage to more effectively consolidate and expand the market to maintain its leading position in the fierce competition. Enhance the degree of standardization in manufacturing products, the difference gradually disappeared, the smaller value-added manufacturing enterprises to join the service elements to seek a greater degree of differentiation, and increase the added value of their products, services business in the manufacturing sector to create the value is increasing. Including a higher degree of customer and market oriented; less standardized and more flexible organization of production; the dominant, etc. as well as incremental innovation, the entrepreneurial spirit of employees also occupies an important position in the manufacturing innovation. At the same time, service innovation is also in some respects to the direction of manufacturing systems, such as more technology is included in the service industry, and innovation activities can be promoted through R & D.

6.2 The Strategy for the Integration of Services Innovation and the Manufacturing Industry

From the logic level of the industrial innovation can be divided into technological innovation, product innovation, market innovation and industrial integration in four phases [10]. Among them, which means the transformation of industrial innovation in the industry between the process of industrial convergence, industrial convergence decide on two factors, first, some industrial innovation will stimulate another industrial innovation chain to have an impact on industrial innovation; the second is industrial innovation will become another industry innovation supply factors, demand – the supply of spiral effect. Industrial integration of the development of manufacturing enterprises in the industrial chain restructuring, rationalization of production organization, and concentrate on training and improve their core competitiveness, but also enables enterprises to make full use of social resources, reduce operating costs. Companies must focus efforts on their core capabilities, which is an important way to survive in the fierce market competition and development, while some of its own is not good business, such as technology development, accounting services, personnel training, IT services to the professional services organization to do, the cost will be lower; the advantages of the integration of the development is also reflected in the can improve production efficiency and product quality, because the producer services and manufacturing sector external business professional level along with the core ability and technology integration and a gradual increase in production efficiency and product quality are bound to improve.

7 Conclusion

With the integration of manufacturing and service industries, the international manufacturing enterprises treat the service as their core competitiveness. The services innovation and integration strategy has become an important source of manufacturing corporate profits in the fierce market competition [11]. Manufacturing enterprise make an application of service innovation requires the guidance of the theoretical model, the four-dimensional model of service innovation because of its built on the basis of the broad definition of service innovation, are applicable to all service-related areas, including manufacturing. The service innovation will become an important source of differential advantage in the manufacturing enterprise, and if the service innovation can be reasonably applied to business, will greatly improve their market competitiveness.

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Low-Carbon Design of Modern Lamps from the View of Material

Hong-yan Xue, Hui Yang, and OTGengNaoRiBu

Abstract With the development of materials science, the role of material in the modern lighting design has become an important part in product visual effects and internal structure. After the Copenhagen climate conference, the low carbon design concept began to be used in lighting design. This paper, through the interpretation of the low carbon design concept and the analysis of the role of material in modern lighting design, makes a preliminary study of modern lighting low carbon design from the material point of view.

Keywords Green design • Low-carbon design • Materials • Modern lamps

Modern lighting products are changing every day. When people walking between the lamp shops, they will be surprised for so many types of the lighting products. The flexible and effective using of material by designers makes some common material became different, and also makes it more intuitive for people to understand the charm of material used in modern lighting design.

The global are paying more attention to the Copenhagen Climate Conference as the greenhouse effect increasing every day. The low-carbon has become the theme of the times. As an important part of the energy consumption, electricity for lighting should be controlled within a reasonable scope. At this point, low carbon design concept begins to be used in modern lighting products.

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1 Overview of Low Carbon Design Concept

1.1 Background of Low Carbon Design Concept

On the Copenhagen Climate Conference which was hold at the end of last year, the major of the energy consuming countries have signed a series of energy-saving and emission reduction agreement. Since then, the low-carbon has become the theme of the times. Low-carbon was known as an economic concept at first. With the time goes by, it was used in product design. Product designers have the social responsibility of protecting environment and advocating users to live a low carbon life, who have made contributions to the changes.

1.2 The Meaning of Low Carbon Design Concept

As a broad social concept of design, low-carbon design, in fact, doesn't have a conventional definition. Low carbon concept is the practice and ideal morphology [1]. But the basis of low-carbon design is the low power consumption, low pollution and low-emission and its nature is the efficient use of energy and the development of clean energy. Ancient China has invented low-carbon design lamps early before, such as Han's Gang lamp (Fig. 1) and Song's Fuel-efficient lamps (Fig. 2).

Fig. 1 Han's Gang lamp

Fig. 2 Song's Fuel-efficient lamps

2 The Method of Selecting Materials Used in Modern Lamps Design in a Low-Carbon Way

The essence of the low-carbon design concept requires designer doing the following tips in selecting and using material of lamps and lanterns:

1. To reduce costs, choose the materials that cost less money, and lower processing difficulty and plasticity.
2. Try to choose environmental friendly, renewable or abandoned materials, in order to improve the utilization rate of material itself, achieving energy conservation and environmental protection;
3. Through the reasonable collocation of material and structure to achieve the energy saving of lamps and lanterns;
4. By simplifying lighting structure with Green-design, not only the transportation, the packaging, and the maintenance become easier, but also reduce the application of materials in order to achieve a low carbon design concept of modern lighting design;
5. Through selecting biomimetic materials, we can evoke survival humanistic awareness of environmental protection.

2.1 Reduce the Costs by Using Different Materials

Before the design of various properties of the product, the choice of materials for production is very important [2]. Since the fire showing up, the history of using lamps has been several thousand years. With the changing of the demand, the

Fig. 3 Mark Andrews chandelier

materials used in manufacturing lamps are changing constantly. Because of the increasing personalized, decorative lighting needs, the modern lighting materials become multifarious. But it can still be divided into five types: metal and imitation metal, plastic, glass, ceramics, wood products, soft materials (such as paper, hemp, rattan, leaves, twigs, leather etc.). In each kind of style, personality for the product will change [3]. The price and plasticity of all these materials determine the cost of the lamps and affect market competitiveness in some way. Therefore, with the low-carbon concept coming up, the designers try to reduce the cost, and begin to choose materials that are inexpensive, easy to process and flexible, such as plastic and paper, as the main material of modern lightings. It not only meets the consumers' personality needs, but also promotes the low-carbon pace.

As one of the representatives of the modern home brand, the production of IKEA is typical. At present, the designers of IKEA mainly choose polypropylene, polyethylene, and paper. Recently it launched an exquisite lighting – Mark Andrews chandelier (Fig. 3).

Its shape looks like the "Dandelion" and it uses the traditional shearing method. And also, they use paper to be their main material. Because paper is inexpensive, easy to process and flexible, the costs and the energy loss are both reduced.

There are many examples about the paper lamps, for example, the famous lighting designers, Sachie Muramatsu, uses the paper to make lamps (Fig. 4) and show the view of nature.

On the market, the number of lamps like IKEA's is increasing. The lighting designers carefully select materials, try to reduce the cost and improve the value of these lightings, and then improve the market competitiveness of the products.

Fig. 4 Lamps designed by Sachie Muramatsu

2.2 Make Lamps More Environmental Friendly by Using Materials

The material's renewability determines the green degree of the material itself and also determines whether the product is environmental friendly. Usually, the green recycled material is divided into two categories: renewable materials and waste materials.

2.3 Selecting Recycled Materials

The choice of materials is an extremely important aspect of low carbon design concept. We must take full consideration of the materials' influence on the environment during the manufacture of the lamps, selling, using, and maintenance and in the written process. Therefore, more and more modern household lightings use renewable materials. It not only improves business efficiency, but also protects the environment. And then, the concept of environmental protection is widely spread.

Fig. 5 Dry seaweed piece wall lamp

Renewable material mainly refers to the renewable recycled material [4]. It can be repeatedly used and still be as a renewable resource for production after the written. And this process consumes little energy. In addition, it will not cause environmental pollution when disposed as rubbish. For example, bamboo, wood, recycled paper, recycled plastic, recycled metal, etc.

Renewable materials can be divided into two categories: natural biodegradable materials and recycling materials [5]. Some designers use natural biodegradable materials, such as bamboo, wood, etc., to reduce the pollution to the environment, and then achieve the function of protecting the environment (Fig. 5), this wall lamp has used piece of dry seaweed produced by Japan as a lampshade, and takes advantage of magnet in metal lampshade frame to stick to the wall. This design is easy for users to demolish lamps, while the other designers choose recyclable or renewable materials to reduce environmental pollution and improve material utilization. Pottery lamp (Growth Series Lamp) (Fig. 6), designed by Dana Otto, all made from recycled paper and there are a variety of shapes. But each one looks exactly like a newly unearthed pottery, often plain. However, when turned on the light, it will completely nirvana and create a warm environment of household.

When talking about the renewable materials of the lamps, most of the LED lamps, which have been rapidly developing recent years, have used environmental friendly and renewable materials. Moreover, the LED light itself is a kind of energy-saving lamp. LED, light emitting diode, is a solid state semiconductor device. It can directly convert the electricity into light [6]. The traditional fluorescent lamp contains a lot of mercury vapor and lead. If broken, lead and mercury vapor can evaporate into the atmosphere, causing serious air pollution. But the LEDs do not

Fig. 6 Pottery lamp (Growth Series Lamp)

contain lead, mercury and other pollution elements, won't make any pollution to the environment. It has strong resistance on impact and lightning strike. At the same time, it produces no ultraviolet (UV) and infrared radiation (IR). The LED bulbs save the energy. Energy consumption of the white LED lamp is only 1/10 of the incandescent lamp, and 1/4 of the energy-saving lamps. As to the longevity of LED bulbs, LED lamp's life can be up to 100,000 h or more. For ordinary home lighting, the LED bulbs can be said to be once and for all.

With the development of science and technology, excellent energy-saving LED lamps have been designed a lot. For example: Dutch designer Bertjan Pot for furniture brand Moooi newly designed LED lamps Heracleum (Fig. 7), the whole light is chandeliered by 63 white LED chips, is like a tree which is turned upside down, covered with light-emitting leaves. Each white leave is in plastic lens shape. The design is both full of simplicity and natural beauty. Israeli designer Aviad Petel exhibited his own LED lamps designed by him in the 2011 Milan Design Week (Fig. 8). Traditional materials of wood, the art of cloth and paper, made up the design – a bendable hose compression LED lights. The whole lamp is made totally by natural handmade materials. Green LED light through a translucent fiber filtration of golden light adds some elegance and warmth to household.

2.4 The Selection of Wasted Materials

The choice of material is the first step of product design [7]. The using of wasted materials is very important part of the low-carbon design concept. Looking for abandoned materials in people's lives and prolong wastes' life cycle in simple ways could save a large amount of money for the whole society. At the mean time, it helps

Fig. 7 Dutch designer BERTJAN POT Heracleum lights

Fig. 8 Designed by Aviad Petel

the protection and development for the environment [8]. More and more designers have noticed and used that in the design of modern indoor lighting creatively. It tells us "wasted" are not really useless, they will be changed into treasure and shine with vitality if they were fully focused on.

As a result of personality and aspiring for environment protection, designers have combined a lot of wasted materials for creating perfect lighting. Such as the Dutch designer Ruddy Grumman's classic milk bottle lamp (Fig. 9) that consists of local recycled milk bottle [9]. These milk bottles have a good sense of light, transparency

Fig. 9 Classic milk bottle chandeliers

and texture. With the lighting effects, the lamp looks simple, graceful and durable. This kind of design not only saves costs, but also fully embodies the designers' awareness of environment production, it helps people to pay more attention to environment protection and to take a part in it.

2.5 Materials and Structures Can Improve the Efficiency of Lambs with a Reasonable Match

Throughout lamps development history, the performance of the lamp as the light source development improves continuously. Since Edison invented a lamp in human history, how to further improve the performance of the lamps has become one of the core issues of lighting designers study. The solution of the traditional method is mainly through the development of light source. Light source has been developed from incandescent bulbs to energy-efficient light bulbs, and now change into the LEDs. The continuous progress of the light source improves the electrical energy into light energy efficiency. But this does not necessarily improve the effective utilization of light energy, and evaluation of the lighting energy efficiency of illumination conditions to meet the requirements of the standard. The system depends on the target illumination area actual the consumption of electrical energy. The consumption of electricity is less, then the lamps gets more energy. Input from the power grid of electrical energy to the human eye perceived brightness of the lamps, the entire lighting system of the intermediate links has great influence on the

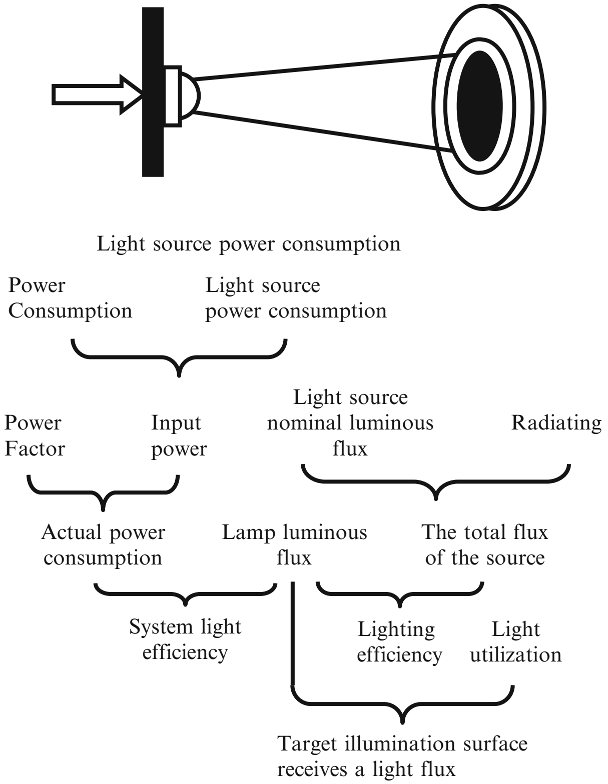

Fig. 10 System light efficiency, lighting efficiency and light utilization

effect of energy-saving lamps. For lamps, the higher the efficiency of the system light and higher light utilization of more energy-efficient lamps emitted, the more energy-efficient [10]. The relationship between the related concepts is shown in Fig. 10.

Therefore, the light source of light is not totally used by people. Only within the scope of the demand of light of people is really effective, and it will depend on the effective structure of lamps and lanterns [11]. PH lamps, as a classic of the history of modern lighting design, Henningsen designed the PH lamps (Fig. 11), with its scientific and humane lighting design and high aesthetic quality known [12]. The one hand, from a scientific point of view, the design makes a soft uniform light through the layer tired lampshade eliminate shadows, and the incandescent spectrum was beneficial compensation, in order to create a more suitable light color. Moreover, it avoids the light stimulation to the eyes. It is more advantageous to the eye and comfortable, which weaken the excessive contrast with the dark background, lamp shade, on the other hand, is designed elegantly, such as smooth elegant lines. The change of the lamp shade, soft and rich color of the light makes the whole design permeated with a full-bodied artistic breath. At the same time, its

Fig. 11 PH lamps, designed by Henningsen

modeling design makes it meet the need of function by using the material, which is conducive to mass production. Because PH lamp has so many advantages, it is called to be interpreted as the Danish design "without time limitation", the best footnote.

2.6 Green Design, Lighting Structure Is Very Simplified to Reducing Material Application

Green design is the inevitable choice for sustainable development [13]. The lamp shape has already got rid of the shackles of the traditional form. The new technology and the changing of people's aesthetic make the shape of the lamps turn to be more and more diversified, individualized, which also enable people to get more emotional experience. Especially as indoor home lighting, its shape is not only beautiful, simple and generous, but also gives people a warm and comfortable feeling, and comfortable, being harmony with the furniture environment, which also express the concept of green design – care for human. In modern interior furniture design, the modeling or some dements of modeling tend to play the role of information transmission. Through the products, people can express or share with family and friends with more spiritual and cultural aspects of things, which make contributions to continuously development of social peace. And this is the purpose of green design. Considering some part of product was discarded or replaced when after used. The designer usually uses the simplest parts [14]. Through green design, the simplify of lighting product's forms and convenience of demolition, makes packaging, transportation and maintenance more easier, and even reduce the costs used in recovering. Thereby, we can reduce the application of materials and show the concept of low carbon design.

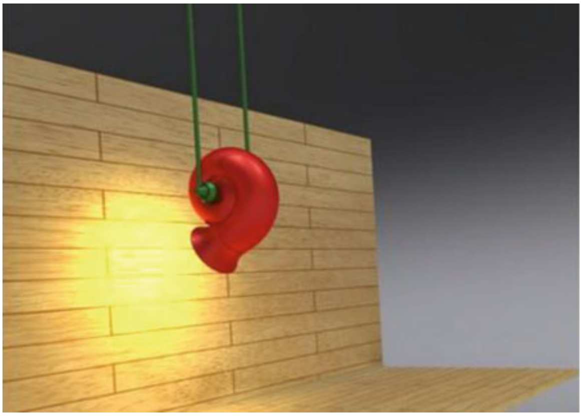

Fig. 12 Conch type lamps

2.7 Choose Bionic Material to Improve Ecological Humanities

Bionic technique applies natural culture symbol to the modern People's Daily necessities, which not only brings people psychological and visual satisfaction, but also an extension of the traditional human nature philosophy and sublimation [15]. As a naturalistic thought, Bionic always has the close relation with design, inspiring creative thinking in the field of the design activities. And lamps and lanterns, as one of the necessities of closely associated with human, closely associated with People's Daily life. So lamps and lanterns design affects people's lives. The design of the product of modern science and technology is the direct media between human and technology to form interaction. It has great significance to apply the bionic material and dynamic bionic design to modern lamps and lanterns design field. It can help to conserve the energy and protect the environmental. At the same time, it can also increase awareness of ecological protection of the humanities. Now, the design of lamps and lanterns uses more and more bionic material, such as the conch type lamps and lanterns design which won the 2010 prize for "Who" (see Fig. 12). It has bright and lively colors, advocating a green consumption concept.

3 Conclusion

Material as one of the important elements of product of lamps and lanterns has a critical influence on the value and attribute of lamps and lanterns. Low carbon design as a new design concept began to receive extensive attention of designers. Low carbon design of lamps and lanterns needs the proper selection of material and the relatively reasonable design of the structure. It makes the lamps environmentally friendly, energy-saving, renewable, low-carbon and green. By this way, we can improve the awareness of the general public on the ecological environment.

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Application of Work Study to the Improvement of PCB-Assembly Line

Xin-xin Han and Xu-hong Guo

Abstract The circuit board final assembly process is discussed as an application example in this study. In order to find the bottleneck stations where the production efficiency are low, work measurement is employed to determine operation time of every station. The paper applies analytical methods of process, operation and movement of work study to analyze the assembly line. Then the technique of 5W1H, ECRS and economic principle of motion is applied to improve the bottleneck. Through good results in comparison with the old scheme, the balance rate is increased and the product efficiency is enhanced.

Keywords Balance rate • Method study • Work measurement • Work study

1 Introduction

Work study includes method study and work measurement [1]. As the core and foundation of the industrial engineering, work study has always been paid high attention. This paper applies the methods of work study to the circuit board final assembly line of a certain electronic enterprise with a series of analysis and improvements. Firstly, in order to find the bottleneck stations and calculate the balance rate, work measurement is employed to determine operation time of every station. And then the paper applies analytical methods of process, operation and movement of work study to analyze the assembly line. With the purpose of solving the problem of low balance rate and product efficiency, the technique of 5W1H, ECRS and economic principle of motion is applied to improve the bottlenecks. In this paper, the method has enlightening and practical value for similar enterprises.

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2 Work Status and Problem Analysis

2.1 Work Status

Due to the increase in customer demands, electronic products of a certain enterprise are in short supply. And only when the production cycle of the products goes down to 11 s or below that, the production satisfies market beat need. The production procedure is distributed into the front-end process and back-end process. The front-end process is surface-mount technology (SMT), and it is production cycle has been lower than 11 s. The back-end process is the circuit board final assembly. Because it is not long until the production line is set up, it is production efficiency is low. In order to achieve the goal of the 11 s, we must take measures to improve the assembly line.

For PCB-Assembly Line, the processing craft route is from outer processing to the assembly with PCB, and eventually to the lid assembly, etc. Before improving, the assembly flow process is shown in Table 1 [2]. Need to explain, manual, machine and manual-machine operation time of every station is measured with Methods Time Measurement (MTM) which belongs to work measurement technique and these data is added wide release rate (2 %) [3]. According to the data from Table 1, the operation time histogram for each station is shown in Fig. 1.

2.2 Problem Analysis

As the Fig. 1 shows, the longest operation time of the production line is in station 10, and the operation time of 19.67 s is the production cycle of the production line. To calculate the balance rate, the computational formula [4] is: the total of operation time/(the longest operating time * number of workstations) * 100 % = 278.2/(19.67 * 22) * 100 % = 64 %. Under normal circumstances, when the production balance rate is between 60 and 70 %, there are the factors that people consciously balance the production line. But some deep-seated problems still are not resolved [5]. On the basis of above conclusions, it is clear that this enterprise has not carried out in-depth management activities on the assembly line. As a matter of fact, most of the operation time is higher than the target.

In order to improve the production efficiency and meet the demand of market, it is necessary to improve the whole production line. The paper uses the analysis tools of 5W1H combined with the economic principle of motion to find points which need improving. According to the actual situation, the following problems are found in the original assembly line:

1. The flow process is unreasonable; there are unnecessary operations.
2. Waste of one-handed operation exists.
3. Some operations do not conform to the economic principle of motion.

Table 1 The original flow process chart

Station No. [8]	Event description	Distance (m)	Operator amount	Time (s)			Symbols [9]				
				Manual	Machine	Manual-machine	○	□	→	⧇	▽
1	Laser engraved code and dispensing		1	4.2	8.0		○				
2	UV glue drying		1	9.1	4.5		○				
3	Welding		1	8.5	3.8		○				
4	Buffer ball assembly		1	4.4	7.0	3.0	○				
5	Air leak test		1	10.4	9.0	4.0		□			
6	Weld visual inspection		1	6.1				□			
7	Coil 1 pre-install manually		1	15.3			○				
8	Coil 2 pre-install manually		1	13.8			○				
9	Coil 3 pre-install manually		1	13.8			○				
10	Coil 4 pre-install manually		1	17.5	2.5	0.3	○				
11	Press-in coil		1	4.9	10.7	4.9	○				
12	Spring 1 assembly		1	10.5	4.4		○				
13	Spring 2 assembly		1	8.5	2.0		○				
14	Pin position examination		1	8.2	5.0			□			
	Move to the next station	2.4	1	1.8					→		
	Take outer and PCB	2	1	2.0					→		
15	Press-in PCB		2	11.8	12.0	11.8	○				
16	PCB visual inspection		2	10.2				□			
17	Laser welding the lid		1	9.9	11.8	9.9	○				
	Move to the scan station	4.6	1	4.3					→		
18	High temperature furnace		1		11.0		○				
	Put in the test station	2.8	1	3.0					→		
19	High temperature test		1	12.4	14.9	12.4		□			
	Put in cooling furnace	2	1	3.0					→		
20	Cooling furnace		1		11.0		○				
21	Sealing ring assembly		1	13.7	3.0		○				
	Functional test		1		6.1			□			
22	Final inspection and packing		2	10.7						⧇	

4. The sequence arrangement of man-machine operations is not reasonable so that the utilization rate of men and machines are very low.

3 Improvement in the Assembly Line

To solve above problems, the technique of 5W1H, ECRS and economic principle of motion is used to improve the assembly line [6].

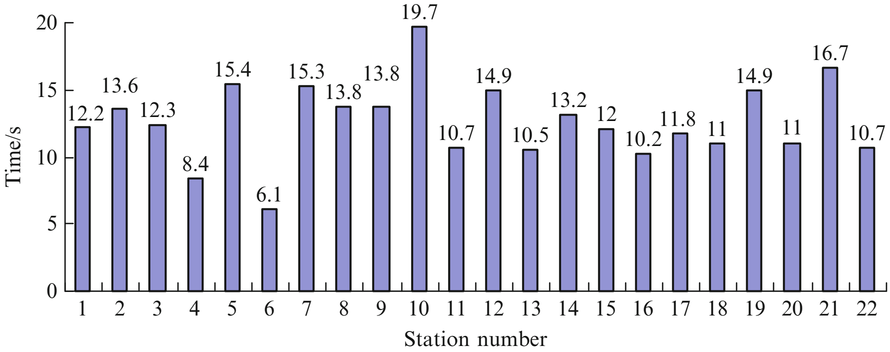

Fig. 1 The former operation time of every station

3.1 Improvement in the Flow Process [7]

1. Cancel the process "Weld visual inspection". The process "Air leak test" is used to check whether welding points leak. In order to guarantee quality, the process "Weld visual inspection" is set to check again whether welding points leak. But in the actual production, nonconforming rate of visual inspection is almost zero, so the process "Weld visual inspection" is unnecessary operation and can be cancelled.
2. Merge some processes. You can see from Fig. 1, there are both no man – machine synchronous operations in "Laser engraved code and dispensing" (process 1) and "UV glue drying" (process 2). When the operator of process 1 is working, the machine has 4.3 s leisure time. And when the machine is working, the operator has 8 s waiting time. On the contrary, the leisure time of machine is 9.1 s and the waiting time of operator is 4.5 s in process 2. The two processes can be merged so that one operator can operate two machines at the same time. By the same token, "Buffer ball assembly" (process 4) and "Air leak test" (process 5)can be merged, merging "Press-in coil" (process 11) and "Spring 1 assembly" (process 12), merging "Pin position examination" (process 14) and "Press-in PCB" (process 15).

3.2 Improvement in Operations

3.2.1 Operations with Both Hands [10]

Waste of one-handed operation exists in "Welding" (process 3) and "Sealing ring assembly" (process 21).

1. The original way of process 3 follows: The left hand stretches into outer boxes waiting for the processing, picks up one of them, moves into the fixed handle

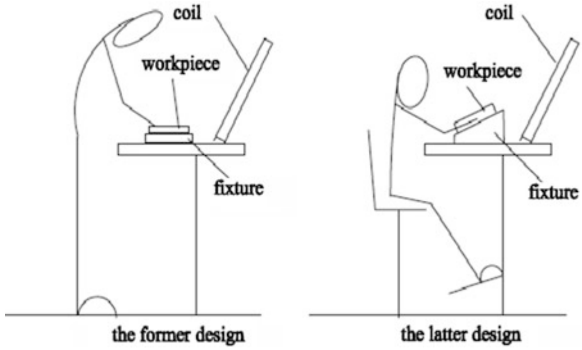

Fig. 2 The former and latter motions

belonging to machine fixture and keeps fixed. Then the right hand with the suction pen reaches into welding points of outer boxes, puts down the sealing fin and exits the work area when the left hand presses the start button. After pressing the button, the machine starts welding. Improved methods: A rubber band which can fix the suction pen on the hand is designed. And the sealing fin can be sucked through the fingers moving the suction pen. Because the pen is small in size, the hand with suction pen can pick up outer box at the same time. To operate easily, the fixed handle can be extended to outside work area.

2. Process 21 exists the following problem: To prevent o-rings falling into other workspaces, the left hand need hold the clamp handle when o-rings are inserted. Improved method: An equipment placing o-rings is designed. With o-rings inside the handle, slide the button to insert o-rings into the fixture, and the funnel which size is greater than 25 mm in diameter can prevent o-rings falling into other workspaces.

3.2.2 Motions Analysis [11]

1. Coil pre-install manually (process 7–process 10) has similar basic motions and is part of meticulous assembly work. The distance between working surface and eyes is too long, causing the operator need bow and lower his head to insert and raise his head to get the coil. From the perspective of human factors engineering, motions are not reasonable. Using economic principle of motion to improve: Considering that the position is fixed and operators does not need to walk, so the four processes can be set to the sitting position and the distance from eyes to working surface is about equal to 40 cm. It is convenient for operators to work. Before and after improvement, the status is given in Fig. 2.
2. Spring 1 assembly (process 12) is used to lift the pneumatic spring into four holes for assembling. As a result, motions include positioning for four times, inserting for four times and separate operation for four times. And the left hand has always been idle. Three screwdrivers are increased into the equipment and four screwdrivers are fixed side by side, and spacing interval is equal to that of

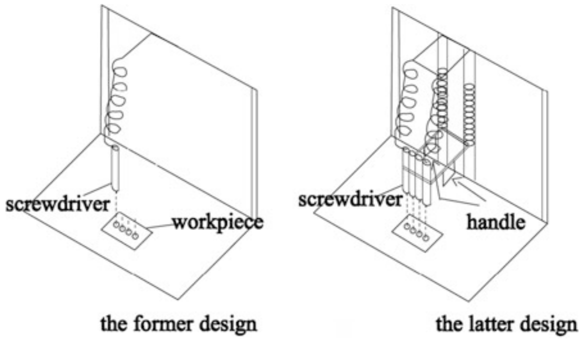

Fig. 3 The former and latter devices

four holes in outer boxes. To reduce weight of screwdrivers, they are fixed with the fixture in 30 cm above four holes. When need to assembly, just hands pull hand lever, complete loosen the hand lever assembly, automatic rising whorls. The former and latter devices are shown in Fig. 3.

3. The process "Press-in PCB" (process 15) whose main job is assembling outer box and PCB and whose operation time is longer, needs improving with economic principle of motion. The manipulator can be split into two parts of input and output. On the left side, the manipulator transport PCB and outer box into machines for processing. On the right, manufactured assembly is inputted with another manipulator. Through improving the layout and machine in itself, the distance is shortened and the utilization of operators and machines.

3.2.3 Manual-Machine Operation Analysis [12]

The original operation of "High temperature test" (process 19) is that: The operator demounts the assembly which has been tested from machine1, puts it into the cooling furnace, takes other assembly to be tested from high temperature furnace, assembles it with machine1, presses the button and machine1 starts testing. Then the operator moves to machine2 for the same work. When one operator operates two machines at the same time, the waiting time and leisure time is longer and the arrangement of manual-machine operation is unreasonable. The improving way is that: Don't need to add equipments and tools, rearrange the operation order and try to use machine working time for manual operation.

3.3 Results Analysis

After the above analysis, Table 2 shows the improved assembly process, and Fig. 4 shows the improved operation time histogram for each station. The balance rate = the total of operation time/(the longest operating time * number of workstations) * 100 % = 181.5/(11.0 * 17) * 100 % = 97 %.

Table 2 The latter flow process chart

Station No.	Event description	Distance (m)	Operator amount	Time (s) Manual	Machine	Manual-machine	Symbols ○	□	→	⌴	▽
1	Engraved code, dispensing, glue drying		1	10.0	8.0	8.0					
2	Welding		1	10.8	3.8	3.8					
3	Buffer ball assembly, air leak test		1	10.9	9.0	9.0					
4	Coil 1 pre-install manually		1	10.5							
5	Coil 2 pre-install manually		1	10.5							
6	Coil 3 pre-install manually		1	10.5							
7	Coil 4 pre-install manually		1	10.5							
8	Press-in coil, spring 1 assembly		1	10.8	10.7	10.7					
9	Spring 2 assembly		1	10.7							
10	Pin position examination Press-in PCB		1	10.9	8.0	8.0					
11	PCB visual inspection		2	10.2							
12	Laser welding the lid		2	9.4	11.0	9.4					
	Move to the scan station	4.6	1	4.3							
13	High temperature furnace		1		11.0						
	Put in the test station	2.8	1	3.0							
14	High temperature test		1	9.2	11.0	9.2					
	Put in cooling furnace	2	1	3.0							
15	Cooling furnace		1		11.0						
16	Sealing ring assembly		1	10.5							
	Functional test		1		6.1						
17	Final inspection and packing		2	10.7							

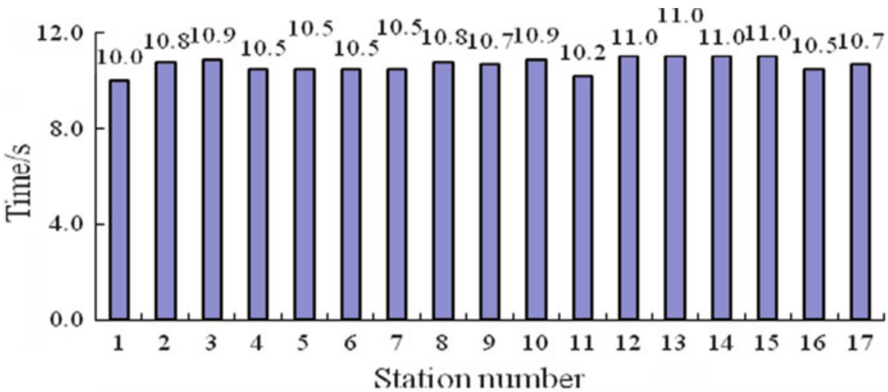

Fig. 4 The latter operation time of every station

Table 3 The contrastive parameters

	No./operator	Distance	Station	Cycle time	Total time	Balance rate
Before	23	13.8 m	22	19.7 s	278.2 s	64 %
After	17	9.4 m	21	11 s	181.5 s	97 %
Effect	6 operators less	4.4 m less	1procee less	8.7 s less	96.7 s less	33 % higher

4 Contrastive Analysis

After the above adjustments and improvement, the following results have been achieved.

In the case of guaranteeing quality, the process is more scientific and reasonable [13]; the labor cost is greatly reduced. Through designing and improving devices, operators make full use of the hands to finish works and have more reasonable and easier operational motions, which make labor intensity of operators reduce and production efficiency enhance greatly [14].

In order to clearly show that improvements, the summary of comparison results in original and latter parameters is given in Table 3 [15].

5 Conclusion

This paper applies the theory and method of work study to the practice of PCB-Assembly line in a certain electronic enterprise. With the minimal or no input, bottleneck stations are solved and the balance rate is increased through the process and operation optimization. The most important thing is that production cycle time achieves the enterprise goal and meets the market needs.

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Nonintrusive Efficiency Estimation of Induction Motors Using an Optimized EKF

Hong-xia Yu, Chuang Li, Yan-hong Wang, and Li Chen

Abstract In this paper, an intelligent optimal EKF (Extended Kalman Filter) algorithm was presented to overcome the defect of getting the noises covariance matrices of EKF by a trial and error method. In order to get optimal parameter of noises covariance matrices by intelligent method, an optimal model was established using the error of estimated speed and torque with measured, then solved by PSO. The efficiency was computed using the estimated speed and load torque by the optimized EKF. Experimental results demonstrated that the estimated efficiency using this method has higher estimated accuracy than EKF.

Keywords Efficiency estimation • Extended Kalman filter • Induction motor • Nonintrusive • PSO

1 Introduction

Electric machines are extensively used as driven equipment in industrial, agricultural and commercial domain etc. In industry, over two-thirds of the total electric energy consumed by motor [1, 2], Energy saving of induction motors are important for overall energy saving. This could be done replacing oversized motors [3] or applying more efficient control techniques [4]. When replacing oversized motors, the operating efficiency of the motor can be used to evaluate the energy efficiency of the motor and provide a reference for choosing a more suitable motor; when it comes to efficient control techniques, the efficiency of the motor can also evaluate the effect of energy-saving control.

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Therefore, a lot of methods are presented to estimate efficiency of motor, Engineers and scholars strive to implement nonintrusive efficiency estimation that is to estimate the efficiency of induction motor does not interfere with the running of motor system in actual industrial field. Lu gives a summary of efficiency estimation methods [5]. The two main methods for non-intrusive efficiency estimated are equivalent circuit method [6, 7] and the air gap torque method [8]. In equivalent circuit method, the efficiency of the motor are calculated using the copper losses and iron loss of motor calculated in equivalent circuit, the mechanical and stray loss using approximation, the parameters of equivalent circuit are identified using stator current, voltage and estimated speed. The nonintrusive air gap torque method is implemented by introducing nonintrusive speed and stator resistance estimation into the air gap torque method, the mechanical and stray loss using approximation. So, these methods have the same problem that the mechanical and stray loss are assumed to be a percentage of the rated power in efficiency estimation.

In recent years, the sensorless motor’s speed estimation methods using EKF (Extended Kalman Filter) was researched by many researchers [9–11] for its good dynamic performance and robustness. The EKF method can estimated motor speed accurately when the motor’s model is imprecise for the motor parameter variation and signal measurement error are account to the noise in EKF Algorithm. But the key problem is that the estimation results of using EKF is greatly affected by the covariance matrices of noise, the improper covariance matrices of noise will make the result of estimation divergence or have large estimate error. The mostly used method of get covariance matrices of noise is to try and regulate according estimate error repeatedly, obviously it is a tedious procedure, Also getting the optimal covariance noise matrices is difficult by this method. To solve this problem, the covariance matrices of noise are got by optimization using GA in [12, 13], the covariance matrices of noise are got by optimization using SA in [14].

The PSO is swarm intelligence method based on the foraging behavior of birds and schools of fish developed by Kennedy and Eberhart, and was widely used in a variety of optimization problems [15, 16] for, its iterative process is relatively simple and faster convergence. In this paper, The noise covariance matrices of EKF was optimized through the particle swarm optimization (PSO). The optimization goal is to make the speed and torque estimation error is minimized, the potential solution of the parameter of noise covariance matrices consist of the search space of the particles. The algorithm avoid the tedious process of trial and error method to obtain the noise covariance matrix, and at the same time you can get a better noise covariance array, the estimation accuracy of EKF using optimized noise covariance matrix are improving effectively.

2 Model of Induction Motor

In the stator stationary frame, the mathematical model of induction motor can be expressed as formula (1).

$$\dot{x}(t) = \begin{bmatrix} \dot{i}_{s\alpha} \\ \dot{i}_{s\beta} \\ \dot{\psi}_{r\alpha} \\ \dot{\psi}_{r\beta} \end{bmatrix} = \begin{bmatrix} a_1 & 0 & \frac{a_2}{\tau_2} & a_2\omega \\ 0 & a_1 & -a_2\omega & \frac{a_2}{\tau_2} \\ \frac{L_m}{\tau_2} & 0 & -\frac{1}{\tau_2} & -\omega \\ 0 & \frac{L_m}{\tau_2} & \omega & -\frac{1}{\tau_2} \end{bmatrix} \begin{bmatrix} i_{s\alpha} \\ i_{s\beta} \\ \psi_{r\alpha} \\ \psi_{r\beta} \end{bmatrix} + \begin{bmatrix} \frac{1}{\sigma L_1} & 0 \\ 0 & \frac{1}{\sigma L_1} \\ 0 & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} u_{s\alpha} \\ u_{s\beta} \end{bmatrix} \tag{1}$$

Where $\psi_{r\alpha}$ and $\psi_{r\beta}$ are rotor flux, $u_{s\alpha}$ and $u_{s\beta}$ are stator voltages, $i_{s\alpha}$ and $i_{s\beta}$ are stator current, ω is angular speed, $a_1 = -(R_1/\sigma L_1 + 1 - \sigma/\sigma\tau_2)$, $a_2 = L_m/\sigma L_1 L_2$, $\tau_2 = L_2/R_2$, $\sigma = 1 - L_m^2/L_1 L_2$, R_1 and L_1 are stator resistance and inductance, R_2 and L_2 are rotor resistance and inductance, L_m is mutual inductance.

The mechanical equation of induction motor can be expressed as formula (2).

$$\frac{d}{dt}\omega = -a_3 i_{s\alpha}\psi_{r\beta} + a_3 i_{s\beta}\psi_{r\alpha} - \frac{B}{J_l}\omega - \frac{p}{J_l}T_L \tag{2}$$

Where J_l is the total inertia of the IM and load, B is mechanical friction coefficient, T_L is load torque, $a_3 = p^2 L_m/JL_2$, p is the number of pole pairs.

In steady-state, the state equation of load torque can be expressed as formula (3).

$$\dot{T}_L = 0 \tag{3}$$

So the extended mathematical model of induction motor including state variables of the speed and load torque of induction motor can be expressed as (4).

$$\begin{cases} \dot{x}(t) = f(x(t), u(t)) = \begin{bmatrix} a_1 x_1 + \frac{a_2}{\tau_2} x_3 + a_2 x_4 x_5 + \frac{1}{\sigma L_1} u_{s\alpha} \\ a_1 x_2 - a_2 x_3 x_5 + \frac{a_2}{\tau_2} x_4 + \frac{1}{\sigma L_1} u_{s\beta} \\ \frac{L_m}{\tau_2} x_1 - \frac{1}{\tau_2} x_3 - x_4 x_5 \\ \frac{L_m}{\tau_2} x_2 + x_3 x_5 - \frac{1}{\tau_2} x_4 \\ -a_3 x_1 x_4 + a_3 x_2 x_3 - \frac{B}{J_l} x_5 - \frac{p}{J_l} x_6 \\ 0 \end{bmatrix} \\ y(t) = h(x(t), u(t)) = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \end{cases} \tag{4}$$

Where $x = \begin{bmatrix} i_{s\alpha} & i_{s\beta} & \psi_{r\alpha} & \psi_{r\beta} & \omega & T_L \end{bmatrix}^T$ is state vector and $y = \begin{bmatrix} i_{s\alpha} & i_{s\beta} \end{bmatrix}^T$ is output vector.

In actual system of induction motor, the process noise $w(t)$, the measuring noise $v(t)$ and the input noise $\zeta(t)$ are considered, so the stochastic model of induction motor can be expressed as formula (5).

$$\begin{cases} \dot{x}(t) = f\,(x(t), u(t) + \zeta(t)) + w(t) \\ y(t) = h\,(x(t), u(t) + \zeta(t)) + v(t) \end{cases} \tag{5}$$

Where, the noises are subject to the following distribution:

$$
\begin{aligned}
&p\,(\omega) \sim N\,(0, Q) \\
&p(v) \sim N\,(0, R) \\
&p\,(\zeta) \sim N\,(0, D)
\end{aligned} \tag{6}
$$

3 Optimized EKF

3.1 Speed and Load Torque Estimation Using EKF

When the speed and load torque of induction motor are the state of system model and parameter of coefficient matrix, the model described by (4) became a nonlinear model, however the EKF (Extended Kalman Filter) is based on the linear model, so the nonlinear model must be transformed to linear model by linearization, the linear model of induction motor can be expressed as formula (7).

$$
\begin{cases}
\delta x(t) = F\,(x(t))\,\delta x(t) + B\,(u(t) + \zeta(t)) + w(t) \\
\qquad\quad = \dfrac{\partial f}{\partial x}\,(x(t), u(t), 0)\,\delta x(t) + \dfrac{\partial f}{\partial u}\,(x(t), u(t), 0)\,(u(t) + \zeta(t)) + w(t) \\
y(t) = H\delta x(t) + v(t) \\
\qquad\quad = \dfrac{\partial h}{\partial x}\,(x(t), u(t), 0)\,\delta x(t) + v(t)
\end{cases} \tag{7}
$$

The computer implementation of EKF algorithm is based on discretization system model, when the sample time is T_s, the linear system model (7) of induction motor are discretized to be the following linear discretization model (8).

$$
\begin{cases}
\delta x(k) = \Phi_k \delta x(k) + M_k\,(u(k) + \zeta(k)) + W_k w(k) \\
y(k) = H\delta x(k) + v(k)
\end{cases} \tag{8}
$$

Where

$$
\Phi_k = \exp\,(F_k T_s) \tag{9}
$$

$$
W_k = \int_0^T \Phi(k)dt \tag{10}
$$

$$
M_k = \int_0^T B\Phi(k)dt \tag{11}
$$

When assumed that the n sampling data is estimated, the implementation process of EKF algorithm based on linear discretization (8) model is as follows:

1. Initialization $X_0, \delta X_0, P_0, Q, R, D$
2. Begin sampling, k = 1
3. State prediction

$$\widehat{X}_k^- = f\left(\widehat{X}_{k-1}, u_k, 0\right) \approx \Phi_{k-1}\widehat{X}_{k-1} + M_{k-1}u_k \tag{12}$$

$$\widehat{Y}_k^- = h\left(\widehat{X}_k^-, 0\right) \approx H_k \widehat{X}_k^- \tag{13}$$

$$\delta\widehat{X}_k^- = \Phi_{k-1}\delta X_{k-1} \tag{14}$$

$$P_{k/k-1} = \Phi_{k-1} P_{k-1} \Phi_{k-1}^T + M_{k-1} D_{k-1} {M_{k-1}}^T + W_{k-1} Q_{k-1} {W_{k-1}}^T \tag{15}$$

4. State update

$$K_k = P_{k/k-1} H_k^T \left(H_k P_{k/k-1} H_k^T + R_k\right)^{-1} \tag{16}$$

$$\delta\widehat{X}_k = \delta\widehat{X}_k^- + K_k\left(\delta Y_k - H_k \delta\widehat{X}_k^-\right) \tag{17}$$

$$\delta Y_k = Y_k - \widehat{Y}_k^- \tag{18}$$

$$P_{k/k} = (I - K_k H_k)\, P_{k/k-1} \tag{19}$$

$$\widehat{X}_k = \widehat{X}_k^- + \delta\widehat{X}_k \tag{20}$$

5. If k < n, then k = k + 1, go to step(3)
6. End

The noise covariance matrix (D, R and Q) can be got by trial and error. The form of the noise covariance matrices are:

$$\begin{cases} D = diag\begin{bmatrix}\xi & \xi\end{bmatrix} \\ R = diag\begin{bmatrix}\lambda & \lambda\end{bmatrix} \\ Q = diag\begin{bmatrix}\alpha & \alpha & \varsigma & \varsigma & \beta & \gamma\end{bmatrix} \end{cases} \tag{21}$$

3.2 Optimized Noise Covariance Matrices

The potential solution of the problem constitutes the search space of particles in particle swarm when the optimization problem was solved by PSO algorithm. According to form of noise covariance matrix D, R and Q, the parameters of the noise covariance matrix needed to be optimized are $\xi, \lambda, \alpha, \varsigma, \beta, \gamma$. So the potential solution space of the problem is 6, whereby the dimension of the particles of the search space can be determined as 6, each dimension of the particles correspond to the parameters of the noise covariance matrix, the i-th particle of particle group can be expressed as:

$$\begin{aligned} X_i &= \begin{bmatrix} x_{i1} & x_{i2} & x_{i3} & x_{i4} & x_{i5} & x_{i6} \end{bmatrix} \\ &= \begin{bmatrix} \xi & \lambda & \alpha & \varsigma & \beta & \gamma \end{bmatrix} \end{aligned}$$

For the optimal goal of PSO is to improve the estimation accuracy of EKF, the objective function is defined using speed load torque estimated by EKF and measured,

$$J = \frac{1}{N}\left(\sum_{i=1}^{N}(n_i - \widehat{n}_i)^2 + \sum_{i=1}^{N}\left(T_{Li} - \widehat{T}_{Li}\right)^2\right) \tag{22}$$

Where, n_i and T_{Li} are measured speed and load torque of motor, $\widehat{n}_i$ and $\widehat{T}_{Li}$ are estimated speed and load torque by EKF.

When the optimal problem is solved by PSO, the PSO method initially has a population of random selective solutions. Each potential solution is called a particle. Each particle is given random position and velocity, then flown towards the target to find the optimal solution of the problem through the problem space. Particle swarm algorithm is widely used in a variety of optimization problems [6, 7] for its iterative process is relatively simple and faster convergence.

Accordance with the objective function, the main steps to optimize the parameters of the noise covariance matrix in the particle swarm optimization are described as follows:

1. Initialize a population of particles. Initialization number of populations is M, and the population is initialized by random positions $x_i(0)$ and velocities $v_i(0)$ in 6 dimensions of the problem space. The optimization algebra is $iter\_\max$, the target of the objective function value is $J_{\min}$;
2. Evaluate the fitness $J(x_i(0))$ of each particle in the swarm. The particle initial value is set to the optimum position of the particles themselves $p_i(0) = x_i(0)$, and to find the optimum position p_g according to Eq. (23) for all particles.

$$J\left(p_g\right) = \min\left\{J\left(x_i(0)\right)\right\}, i = 1, 2, 3, \cdots, M \tag{23}$$

3. Change the velocity $v_i(v_{i1},v_{i2},v_{i3},v_{i4},v_{i5},v_{i6})$ and position of the particle $x_i(x_{i1},x_{i2},x_{i3},x_{i4},x_{i5},x_{i6})$ according to Eqs. (24) and (25) respectively.

$$v_{id}(k) = wv_{id}(k-1) + c_1r_1(p_{id} - x_{id}(k-1)) + c_2r_1\left(p_{gd} - x_{id}(k-1)\right) \tag{24}$$

$$x_{id}(k) = x_{id}(k-1) + v_{id}(k) \tag{25}$$

Where: v_{id} and x_{id} represent the velocity and position of the ith particle with d dimensions respectively. r_1 and r_2 are two uniform random number, and w is the inertia weight, c1 and c2 are learn factor.

4. Update the optimal location of the particle itself p_i. For every iterations, the optimal location obtained by compare each particle's fitness with its previous best fitness.

$$p_i(k+1) = \begin{cases} p_i(k) & J(x_i(k+1)) >= J(p_i(k)) \\ x_i(k+1) & J(x_i(k+1)) < J(p_i(k)) \end{cases} \tag{26}$$

5. Update best location of all particles p_g. Compare best fitness of particles with each other and update the swarm global best location p_g.

$$J\left(p_g\right) = \min\{J(x_i(k))\}, i = 1, 2, 3, \cdots, M \tag{27}$$

6. If $J(p_g(k)) < J_{\min}$, then go step (8);
7. If $k < iter\_\max$, then k = k + 1, turn to step (3);
8. The optimization results is given, the end.

4 Nonintrusive Efficiency Estimation

After speed and load torque are estimated using PSOEKF, The efficiency estimation value can be calculated by formula (28) through substituting T_L and n with the steady-state mean value of the estimated speed $\widehat{n}_i$ and load torque $\widehat{T}_{Li}$, the steady-state mean of speed and load torque are defined as formula (30) and (31).

$$\eta = \frac{P_{out}}{P_{in}} = \frac{30}{pi} \cdot \frac{T_L{}^* n}{P_{in}} \tag{28}$$

Where input power can be calculated as follows:

$$P_{in} = \frac{\int_0^T (v_a i_a + v_b i_b + v_c i_c)\,dt}{T} = \frac{\int_0^T (v_{ab} i_a - v_{bc} i_c)\,dt}{T} \tag{29}$$

$$\overline{\widehat{n}} = \frac{1}{2,048} \sum_{i=2,049}^{4,096} \widehat{n}_i \tag{30}$$

$$\overline{\widehat{T}}_L = \frac{1}{2,048} \sum_{i=2,049}^{4,096} \widehat{T}_{Li} \tag{31}$$

5 Experimental Results

Figure 1 shows the bench, an induction motor (Y100L2-4) drag a DC generator (Z_2-42), a precision torque meter and the voltage and current sensors are equipped in bench. The nameplate parameter of induction motor and DC generator are given in Table 1. The induction motor parameters are $p = 2$, $R_s = 2.0713\ \Omega$, $L_s = 0.241929H$, $R_r = 1.7148\ \Omega$, $L_r = 0.242007H$, $L_m = 0.232559H$, $J_l = 0.02\ \text{kg} \cdot \text{m}^2$, $B = 0$.

The load of induction motor are changed by changing the excited voltage of the generator, and stator instantaneous line voltage(v_{ab}, v_{bc}), instantaneous phase current (i_a, i_b, i_c), speed (n) and load torque (T_L) are collected at different excitation voltage(EV), The sampling period is 1/4,096 s, Acquisition time is 1 s. The calculated data using measured value by formula (28), (29), (30), and (31) at different load are shown in Table 2.

Fig. 1 Bench of induction motor

Table 1 Nameplate data of motor

Motor	P_N (Kw)	I_N (A)	n_N (rpm)	η_N (%)	cos φ_N	λ
Y100L2-4	3	6.8	1,420	82.5	0.81	2.3
Z_2-42	4	220	22.3	1,500		

Table 2 Calculated values using measured value at different excited voltage

EV (V)	$\overline{n}$ (rpm)	$\overline{T}_L$ (Nm)	P_{in} (W)	η (%)
0	1,495.7	0.76	392.04	30.35
25	1,488.1	2.52	634.02	61.90
50	1,474.3	6.15	1,242.72	76.35
75	1,463.1	9.92	1,917.08	79.24
100	1,455.1	13.03	2,469.88	80.39
125	1,445.2	15.59	2,912.19	80.97
150	1,435.0	17.72	3,269.54	81.4
175	1,428.1	19.25	3,560.91	80.8
200	1,421.1	21.01	3,871.67	80.71

Table 3 Optimized parameters of noise covariance matrix

EV (V)	ξ	λ	α	ς	β	γ
0	6.06e-06	5.52e-07	7.21e-04	0.9754	0.6395	9.4995
25	9.43e-07	4.69e-07	2.75e-03	0.8401	0.9371	9.8133
50	6.07e-06	7.30e-07	1.53e-03	1.2973	0.6362	0.2992
75	9.81e-06	7.98e-07	2.70e-04	1.3754	0.0017	0.3763
100	4.39e-06	6.29e-07	9.99e-04	0.9.695	0.4093	9.9535
125	6.85e-06	6.20e-07	7.47e-04	0.7271	0.5396	1.5550
150	7.86e-06	1.37e-06	8.00e-04	1.1800	0.2578	1.8857
175	3.84e-06	4.92e-07	2.90e-03	0.4064	0.2533	5.9555
200	2.71e-06	4.61e-06	5.23e-04	1.8459	0.5864	1.4846

In experiment, the population number M is initialized 20, Optimization algebra is 2,000, the target of the objective function value is 0.00001, Inertial weight w is chosen 0.8. learn factor c1 changes adaptively in the formula (32) with an initial value of 2, and c2 is set a constant 2.

$$c_1 = 2\,(1 - iter/iter - \max) \tag{32}$$

The initial value is selected as follows in EKF:

$$x(0) = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$P(0) = diag\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix} \cdot 1e^{-10}$$

Table 3 give the optimized parameters of noise covariance matrix using PSO, Fig. 2 give the estimate results of speed and load using PSOEKF at different excited voltage. Table 4 give the estimate error of speed and load torque at different excited voltage, the error is computed according to the formula (33) and (34). From Table 4, the PSOEKF has higher precision than EKF.

$$e\widehat{\overline{n}} = \overline{n} - \widehat{\overline{n}} \tag{33}$$

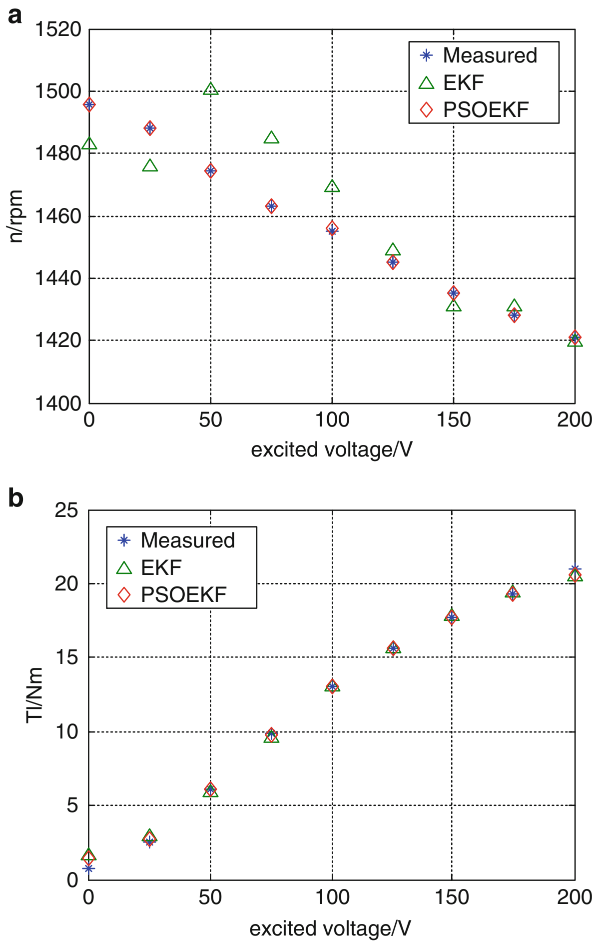

Fig. 2 Comparison of estimate results at different excited voltage. (**a**) Comparison of speed. (**b**) Comparison of load torque

$$e\overline{\widehat{T}}_L = \overline{T}_L - \overline{\widehat{T}}_L \tag{34}$$

The efficiency was computed using estimated speed and load torque according formula (28), (29), (30), and (31). Figure 3 gives the estimate results comparison of efficiency using PSOEKF at different excited voltage. Table 5 give the efficiency estimation error at different excited voltage, in table 5 efficiency error is defined as formula (35). Table 5 show the proposed PSOEKF method higher precision than EKF.

$$e\widehat{\eta} = \eta - \widehat{\eta} \tag{35}$$

Table 4 Estimate error of speed and load torque at different excited voltage

	EKF		PSOEKF	
EV (V)	$e\overline{\widehat{n}}$ (rpm)	$e\overline{\widehat{T}}_L$ (Nm)	$e\overline{\widehat{n}}$ (rpm)	$e\overline{\widehat{T}}_L$ (Nm)
0	12.7	−0.84	−0.28	−0.66
25	12.1	−0.4	0	−0.2
50	−25.88	0.26	0	0.04
75	−21.86	0.35	0	0.11
100	−13.16	−0.01	−0.05	−0.02
125	−3.55	0	0.2	−0.01
150	4.13	−0.1	0	−0.03
175	−2.92	−0.11	0.13	0
200	1.55	0.55	0.14	0.44

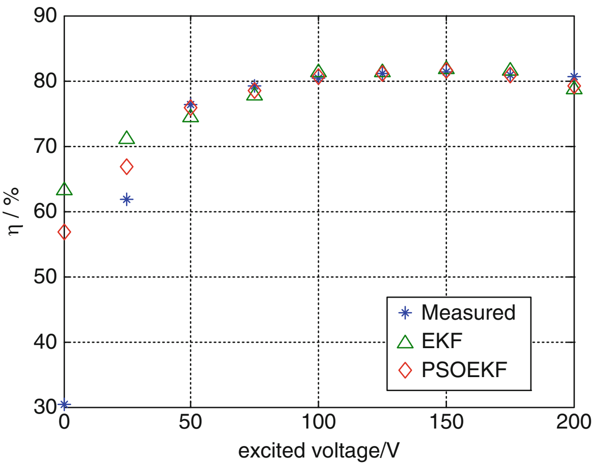

Fig. 3 Comparison of estimate results of efficiency at different excited voltage

Table 5 Estimate results of efficiency at different excited voltage

	$e\widehat{\eta}$ (%)	
EV (V)	EKF	PSOEKF
0	−32.95	−26.53
25	−9.18	−4.91
50	1.88	0.45
75	1.57	0.87
100	−0.83	−0.15
125	−0.23	−0.09
150	−0.27	−0.17
175	−0.66	−0.05
200	2.13	1.65

6 Conclusion

This paper presents a nonintrusive efficiency estimation method of induction motor based on PSOEKF. The nonintrusive efficiency estimation of motor is implemented by estimating the speed and the load torque of the motor using PSOEKF. The PSOEKF get the optimized noise covariance matrices by minimizing the objective function that defined using speed load torque estimated by EKF and measured using PSO. The proposed method avoid using approximate value of stray loss in the conventional efficiency estimation method, and overcome the defects of getting the noise covariance matrices by trial and error in EKF method, The experimental results show that PSOEKF with the optimized noise covariance matrix has higher estimation accuracy.

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Design of VAV BOX Controller Based on Fuzzy-PID Hybrid Control

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Abstract Hybrid fuzzy-PID controller is a controller that makes fuzzy and PID controller in parallel, it adopts fuzzy control when away from the operating point taking the advantages of solving the nonlinear uncertainty with fuzzy controller. And it adopts PID control around the work area by using PID to control the characteristics of high precision. The fuzzy PID controller is applied to the VAV BOX for many factors influenced by VAV terminal control. It effectively solves the problems of the VAV air conditioning system which is lag, big inertia, random interference and nonlinear. In addition it is verified in the VAV air conditioning test platform, and achieves the expected control effect.

Keywords Fuzzy control • Fuzzy-PID control • Variable air volume • VAV BOX

1 Introduction

Variable Air Volume (VAV) system automatically adjusts room temperature according to the requirements of air conditioning room load and parameters indoor. Mainly control circuit in VAV includes the terminal part (VAV BOX) and some units according to distribution location. VAV BOX is directly connected to the room and adjusts the supply air volume, compensates the change of indoor load, and adjusts the room temperature [1]. Therefore, VAV BOX is one of the important devices can

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best embody the effect of control system, determines the specific ways and effect of the whole system control.

There are many factors to affect the VAV BOX control, Including the nonlinear caused by differences in feeding the wet bulb temperature and large delay, change of supply air duct pressure and staff and random disturbance. Traditional VAV BOX controllers mostly adopt the constant PID parameter control mode, so that the system can get the best control effect only in a certain condition. Chen Kaizuo et al. established a mathematical model of pressure independent VAV BOX, and a simulation study, the steady-state performance of VAV BOX were obtained, but lack of practical verification [2]. Tolga. N for office model as the research object, simulation of the office equipment, lighting equipment, and considering the interaction of temperature and humidity. Compared with the actual situation, to verify the correctness of the simulation model and experimental, but he only consider the cooling season [3]. Chen Wu et al. established dynamic pressure VAV model of independent terminal, this model can reflect the real end because the wind valve connecting mechanical hysteresis, motor action process, implementation of dynamic characteristics of initiator is not sensitive area [4]. Hu Yuling adopted the fuzzy neural network control to the end of VAV air conditioning control system, the experimental results show that it is better than traditional control method [5]. Li Weifeng, Huang Lei, by increasing the online fuzzy adjustment of quantization gain and gain ratio, in on the basis of simple fuzzy control adaptive fuzzy control theory, and is used in the control of VAV terminal unit. The experimental results show that, this is to improve control precision of VAV air conditioning, play energy saving potential in VAV air conditioning, has good effect [6]. Stanke D proposed a dual duct VAV air conditioning systems, cooling and heating part can adopt different fresh air ratio which can improve the efficiency of ventilation system, is a true realization of the VAV air-conditioning system of the whole air [7]. Liu Guopeng put forward two fan control method, a system optimization, another for keeping the differential pressure set point, compared with the conventional method of two kinds of methods to increase of the opening degree of terminal device. The method is applied to the system with DDC control and pneumatic control terminal device can reduce energy consumption and improve the system efficiency [8]. WangJun through state feedback decoupling and genetic algorithm improves the accuracy and performance of indoor air temperature air conditioning system [9]. The literatures [10, 11, 12] on air handling unit and adjusted rooms multi-loop PID control has been carried out, a lot of strong interference is very good inhibition of air conditioning system, but could not accurately, reasonably determining the parameters of the controller. The literatures [13, 14] will be fuzzy inference system is applied to the control of air temperature, can make full use of prior knowledge, accelerate the speed of learning.

Therefore, according to the running characteristics of the VAV system, this article adopts the hybrid fuzzy-PID control, so it not only has the fuzzy control to solve the nonlinear uncertainties and has the advantages of strong robustness PID control, and has characteristics of high control precision in operating point. Verified in VAV air conditioning test platform show the effectiveness and feasibility of this control method.

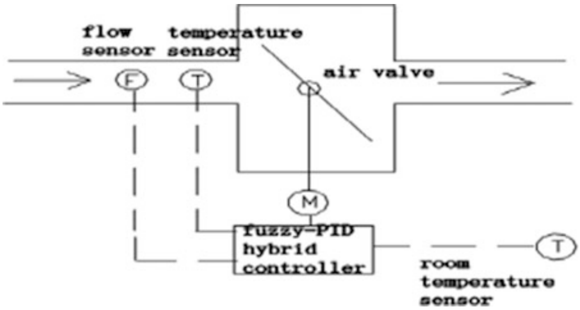

Fig. 1 The structure diagram of VAV BOX

2 VAV BOX Control Structure

VAV BOX can accept temperature and air flow control instruction. When the indoor load increases, it can automatically keep the room ventilation and shall not exceed the maximum design air flow; when the indoor load decreases, it can maintain the minimum air volume, in order to meet the minimum fresh air volume and air distribution requirements; when not in use, it can completely shut down some end of the device air valve terminal device also has two return, reheat and air filtering and other functions. The VAV BOX consists of the controller, air valve drive, air valve, temperature sensor, flow sensor etc. The structure diagram is shown in Fig. 1.

3 The Controller Design

3.1 Mixed Fuzzy PID Controller Structure

According to the characteristics of VAV air conditioning system, a mixed controller of fuzzy control and PID control are designed.

Fuzzy-PID hybrid controller is the fuzzy controller and PID controller in parallel, and the choice of what kind of controller is composed of a control switch, it can obtain good dynamic performance when the system deviation away e_0 by using fuzzy control, when the system deviation in the threshold is within e_0, it can make the system obtain good steady-state by performance using the PID control.

3.2 Fuzzy Controller Design

The fuzzy controller using two-dimensional structure, takes the room temperature deviation and deviation of temperature change rate as the input of fuzzy controller, so that it can control the amount of u as the output of fuzzy controller, which can avoid the one-dimensional fuzzy controller is poor control performance and multi-dimension fuzzy controller control algorithm is difficult to achieve.

The temperature deviation is defined as e, temperature deviation change rate is defined as EC, control is defined as the amount of u, they will be fuzzy set and its domain is defined as follows:

E, EC and u fuzzy sets were: {NB (negative big), NM (negative medium), NS (negative small), ZO (zero), PS (positive small), PM (positive medium), PB (positive big)};

Combined with the dry-bulb temperature, wet-bulb temperature and air velocity effect on the human body heat and cold feeling, and according to the GBJ19-87 "heating ventilation and air conditioning design norms" provisions, the summer air conditioning indoor temperature should be 22–26 °C, the winter temperature should be 18–22 °C, so the domain of E setting for [−8 8]; field theory EC setting for [−8 8]; field theory u setting for [0 10], so that it can fully meet the requirements of human body.

Determination of membership function: according to the characteristics of the central air conditioning system for E and EC, we choose the Gauss function as membership function, Gauss membership function vertex is relatively smooth, not only to meet the speed requirements of the fuzzy controller, and can avoid the jitter. While for the combination of u selection of triangular and trapezoidal membership function, it can avoid the frequent movement of controlled object near the temperature setting.

The establishment of fuzzy control rules: according to the experience of designers and technical knowledge and operating personnel to establish an appropriate fuzzy control rules. When the air conditioning room temperature far exceeds a set temperature and also rapidly increases, the air valve opening adjustment to the maximum of wind; if the actual temperature in air-conditioned room is far greater than the set temperature and rapid decreases, the air valve opening to the secondary air flow, so as to summarize a fuzzy conditional statements set, and the establishment of fuzzy rules, the fuzzy rule base in MATLAB, the design of a total of 49 fuzzy rules.

4 The Verification of Controller Design

4.1 HVAC Comprehensive Experimental Platform

Central air conditioning experimental platform hardware provided by laboratory mainly includes each one of the refrigeration unit, cooling tower, air handling unit, and the wind pipe and water pipe which are used to connect the above things and two areas used to simulate the air conditioning room.

Fig. 2 Air valve of experimental platform

In the terminal device controller, we adopt the PCI1710 board of Advantech series, it is data acquisition card with 12 bits PCI bus. It has 16 single-ended analog inputs used to collect the room temperature, air temperature, air supply pipeline pressure, air valve feedback open degree feedback data, and it also has 2 Road 12 analog output is mainly used to control air valve and AHU fan frequency.

VAV terminal is the executive body of the terminal system. The opening (0–100 %) is composed of a voltage of two 10 V to control; open degree feedback is one of 0 corresponds to 10 V (0–100 %) voltage signal. The actual experiment control platform and air valve is shown in Fig. 2.

4.2 Fuzzy PID Controller Verification

Using Advantech multifunction data acquisition card to collect the data of industrial control computer and through the Matlab industrial control computer software experimental platform in the Real-Time-Target toolbox, the design of hybrid fuzzy PID controller has good deal with the collected data, adjusting air valve opening according to the room temperature value.

Condition 1: cooling process simulation of summer air conditioning room, cooling load of the experiment platform is 0.65 KW, supply temperature of chilled water is 7 °C, mixed wind temperature entering the cooling coil remains at 24 °C, the humidity of the room is 40 %, room temperature is 28 °C, while the temperature of the room is set to 22 °C, the actual temperature control chart of fuzzy PID hybrid control is shown in Fig. 3.

Condition 2: cold load of the experiment platform is 0.65 KW, supply temperature of chilled water is 9 °C, mixed wind temperature entering the cooling coil remains at 24 °C, the humidity of the room is 40 %, room temperature is 28 °C, the actual temperature control chart of fuzzy PID hybrid control is shown in Fig. 3.

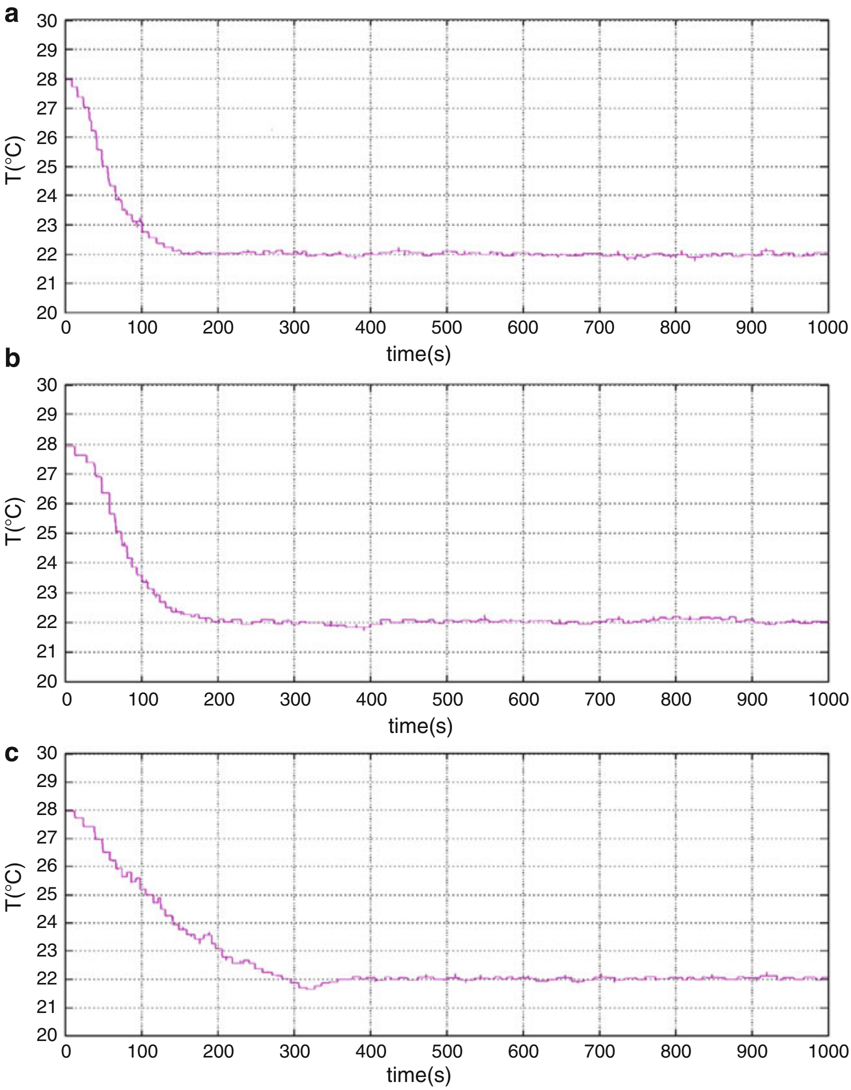

Fig. 3 Experimental curve

Condition 3: cold load of the experiment platform is 0.65 KW, the supply temperature of chilled water on the experimental platform is always maintained at 9 °C, mixed wind temperature entering the cooling coil remains at 24 °C, the humidity of the room is 40 %, room temperature is 28 °C, at the same time, the temperature of the room is set to 22 °C. This experiment is mainly to simulate the influence on the air conditioning system at rainy weather or the increase of humidity caused by human factors. Mixed fuzzy PID control experiment is shown in Fig. 3.

Table 1 Experimental analysis table

Experiment	Stability	Regulated time (s)	Overshoot	Steady state error
Condition 1	Stable	160	0	0
Condition 2	Stable	200	0	0
Condition 3	Stable	350	3 %	0

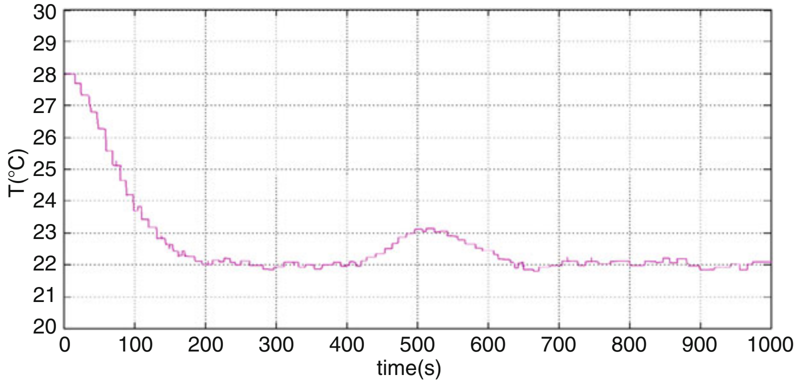

Fig. 4 The actual temperature change curve under the condition of increasing the cooling load

The system performance index of three experimental columns was compared in Table 1:

The experiment condition and Experiment 2 under the same cooling capacity, joined 200 W in 400 s near the load to simulate indoor office equipment to open or personnel appear interference increases when the situation, fuzzy PID hybrid control experiment is shown in Fig. 4.

5 Conclusion

Hybrid fuzzy PID controller designed in this paper can make the system more stable under a variety of circumstances, and have shorter adjusting time, smaller overshoot, higher steady-state accuracy. Temperature of chilled water has a great effect on the adjusting time of the central air-conditioning system. Lower the temperature of chilled water, shorter the system adjusting time, on the contrary longer the adjusting time. The air humidity of the room also has an effect on the adjusting time of the system. Lower the humidity in the room system, shorter the adjusting time, on the contrary longer the adjusting time. Besides, hybrid fuzzy PID controller designed in this paper is robust.

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Research of CRM/ERP Integrated Systems for New Materials SMEs with Scattered Customers

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Abstract Customer relationship management (CRM) is inseparable from enterprise development, customizable CRM software of small and medium-sized enterprises (SMEs) has become a trend for the problems in scale and standardization, especially for these SMEs in sophisticated technology. In the paper, a CRM and ERP integration system is proposed by the application in a new material company. Because of the combination with the competition in the market and the company's operation situation, the personalized enterprise workflow is presented by special needs in this company. Moreover, the methods of modular design and the functionality integration theory of CRM and ERP are made the system user friendly and scientifically. By the integration of these modules, the system has met the business needs in the special processes in relevant department.

Keywords CRM • SMEs • Modular design • Demand analysis • Functionality integrated theory of CRM and ERP

1 Introduction

Along with social progress and the development of world economic integration, the competition among enterprises is increasingly fierce, The traditional business model of a fundamental change occurred, Enterprise competition developed from "product-centric" to "customer-centric". Due to the rapid development and applications of the technology of computer, communication and network, to choose products and services become more and more easy. In this case, how to build and maintain customer relationships, how to improve customer satisfaction and

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loyalty and ultimately improve the competitiveness of enterprises has become an important issue that was placed in front of the corporate [1]. CRM is a method to acquire customers, and increase the number of profitable customers too [2]. The earliest CRM originated in the United States, primarily focus on customer segmentation management. Now it has become a leading, customer-centric business management theory, and it is also a kind of specific software and implementation methods to improve the income of enterprises by improve customer satisfaction via the information technology [3]. Since 1999 Gartner Group Inc put forward the concept of CRM, the CRM market has been in a state of an explosive growth. In recent years, foreign CRM industry has been a very high level of development. The domestic market, by contrast, has great potential, but lack of heat in enterprise users.

After the trend set off by CRM in large enterprises, today's development for supporting vendors has gradually become mainly by the large quantities of demand of SMEs. Significantly different from China's large enterprises in the areas of management, finance, human resources and market, SMEs' generally management tools is relatively backward and the sales management is not standard [4]. Although there are number of CRM software on the market, and be constrained by the normalization process of large enterprises, but few truly fit the needs of the status of SMEs. The available CRM and SMEs has a low compatibility. CRM software market varies greatly, there are many difficulties and problems, but the reality is not whether to use the CRM system or not, but how to make good use of CRM [5]. Thus in a few years ago, the development of the CRM software for SMEs has become a hot research topic in the research and development, the research and development about on-demand CRM plays an important role in the theoretical development and practical application of the CRM of SMEs. Requirements of sophisticated science and technology enterprises is one of the most complex requirements, they have unique difficulties and problems of their own. For those enterprises that have not or are considering establishing ERP, CRM building process must be taken into account the integration of the two [6–9].

The targeted company in this paper is a sophisticated technology company professional in R & D and product new materials tape. As there are many differences in the characteristics of industry and types of customer, the construction of information systems is more difficult than that in other industries. The company's workflow conflict is due to internal demand, it's difficult to regulate. The trials of CRM software failed to meet the demand. The article firstly discussed the CRM and ERP theory of SMEs, CRM and ERP combining design concept, etc. Then analysis to understand the business development status and contradictions of demands, and conduct a in-depth study about the development of CRM for new materials R & D technical SMEs. Through a detailed demand analysis for customers to establish their precise needs, use the modular design method, summed up the specifications for the target enterprises business processes, create unique software functional modules, meet the demand for design CRM for the special needs of technology-intensive enterprises. This paper has presented functional integration of ERP and

CRM system On the basis of requirements, there is no existent border between them, and the functions that business needs belong to ERP in the software have been implemented, such as internal processes function, security function.

2 Demand Analysis of CRM System

Functional requirements analysis for the system [10, 11]: the company has just been established, it is still in the growth stage, and it is in the first place in China that capable of producing Teflon tape. It belongs to technology-intensive small and medium-sized enterprise, the company conducted its own R & D team to research and development, its products are sold at home and abroad, over a very wide range of applications. Its main business is in the form of B2B, primarily for the enterprise. Its customers add the company's products into their own products, and then sold to other customers or enterprises to win profits or access to services. The company's customers have some characters, such as across the country, scattered, less demand for the products, but because of the strong competition for the company's products, the customers' demand are very stable. There are also the limitations of development for CRM system from previous analysis. The company had tried several CRM systems, their basic CRM functionality can be used, such as customer information management, sales management, but some functionality nominally exists are not available. Including, but not limited to, the following question: No person in charge of storage and no product unique number in Warehouse Management module. Their software operating authority function greatly does not comply with the requirements of the company, there is no strict and clear distinguished permission, any user can access software could operate most of the functionality, it is not conducive to the hierarchical management of software functionality within the enterprise. Most software do not reflect the work process, even if there is, they also can not fit reality, the much-needed processes of software process management are handling of complaints, after-sales, finding and managing sales opportunities, out-put and in-put of sales and warehouse management, contract approval process and so on. In summary, the problems of the company can be grouped into the following broad categories: (1) Difficult to regulate processes: Notwithstanding the company have its own set of work processes, with the widening of businesses and organizations, the process has not been documented yet, and the company itself still belongs to small and medium-sized enterprise, operational flexibility, this cause the phenomenon that it is not easy to regulate the workflow to integrity and unity; (2) The company's Sophisticated technology need to be kept confidential, but had to present their Non-confidential personnel access to the company's confidential technology by go through the sales process or production processes. This is the company's internal contradictions.

Demands analysis for the company: to communicate with the warehouse management, sales staff, sales logistic personnel, sales manager, general manager and other personnel, get the demand and comprehensive consider the characteristics of the industry. According to the process we need to have the following functions: (1) the contract need to be very clear comply with the process of company's organization approval, sign and save; (2) handling problems in Sales: Pre-sales opportunity process, complaint handling in sale and after-sales service, records, submitted, solve, archive of complaints, etc.; (3) management for customer rebate, commission statistics; (4) the need to add warehouse management, Integrated software product management and storage management into the CRM software to facilitate staff operating as multiple roles; (5) other process details. In addition, the permission settings of the software are divided strictly in accordance with the direction of the workflow. Demand of other aspects: Before propose CRM solution, we must not only ensuring the functionality of CRM software to meet the functional requirements of the enterprise, but also taking into account to ensure that consistent with the development plan of enterprises. In general, to achieve to be an economic, practical, targeted quality program, firstly CRM of SME needs to be with features like simple, easy-to-use, short implementation cycle, easy maintenance, etc. [12]. The company's products are in less product range, easy to manage, with a small amount of data. In the longer term there is no demand for remote operation, therefore there is no special needs for system performance and system data.

After the demand analysis, we determined toward or contents, the details of the functional requirements and permission requirements of the business processes. Drawn the detailed understanding of the results of demands analysis into the specific needs of illustration, and add the privileges assigned demand. Now cite the analysis results of the specific needs of the customer management, as Fig. 1.

The figure integrates a variety of customer-related information needed by company into several function points. Each key point contains detailed functional classification and description. The figure shows the links with the various functional points, among them the customer data register basic information of customers who deal with our company, the function block content which is the foundation for managing the others information of customer, mutual jumps to other function blocks which are all linked by the basic function block. So that you can open quotation, contracts, complaints and other information in the sales process via the customer data being viewed.

3 Modular Expression the System

After develop business processes clearly, using modular design method to conduct block design [13], to be fully prepared for the establishment of workflow management [14, 15]. The module design reduce the complexity, make it easy to maintain, modify, the parallel development of different parts which the support system is easier to implement, that will help to improve product quality, shorten the design time of the system, which will help the software replacement. Main ways to design

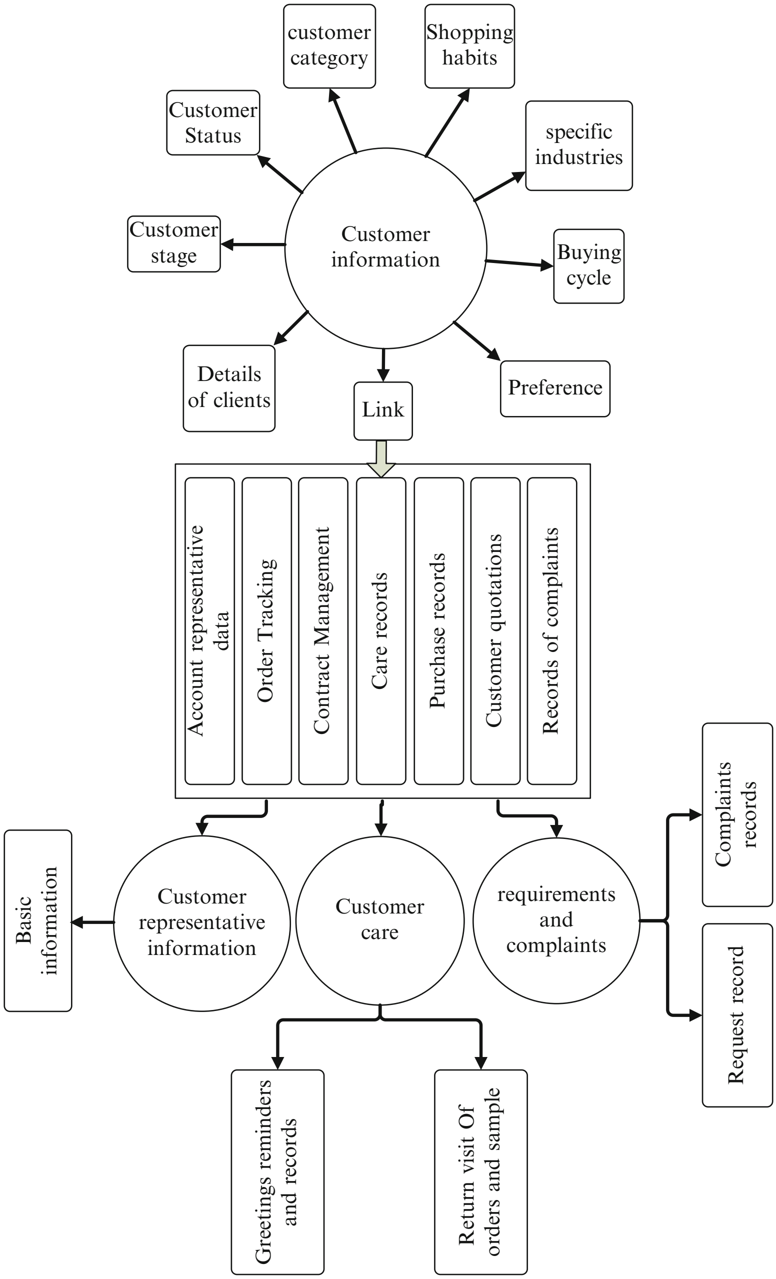

Fig. 1 Illustrations on the specific needs of the customer management

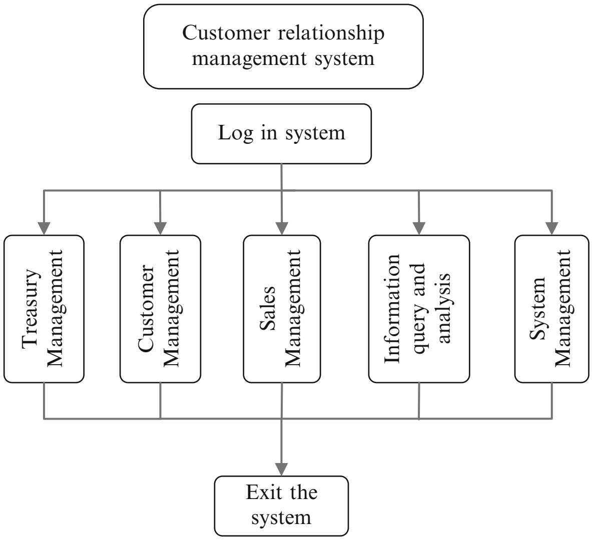

Fig. 2 Customer relationship management module

modularized: (1) cross-series modular design; (2) vertical range of modular design; (3) a full range of modular design. In this paper, we choose the cross-series modular design. Use the existing CRM software modules develop deformation products without changing its main parameters. Replace or add modules in the original type software, generate suitable CRM software for the new materials company. The design principles are: to make products keep high precision, stable performance, simple structure, low cost based on the meet of the requirements of products, module structure and links between modules should be as simple as possible, standardized.

We establish the following modules from business process analysis and management needs: (1) system management module: landing permissions settings, assign permissions management; (2) Customer management service modules: Customers detailed basic information, customer shopping habits, customers VIP level management, customer care reminders, customer visits, customer suggestions records, customer complaints, etc.; (3) Warehouse management module: contains the storage process and product management processes, can contact the production update product demand at any time; (4) Information query and analyze module: connotation data mining, data analysis; Containing both sales back office performance combined with ERP, summary report statistics, facilitate the management of the company to appraisal employee performance and rapid response to sales data; (5) Sales management module: includes sales management in pre-sales opportunity marketing and in sales, order tracking included in the process, after-sales management, contract management, and other content.

The established customer relationship management module, as shown in Fig. 2:

The first two modules are the type of basic function module of CRM; the last three modules belong to modules combined with function of ERP. Use the function to make the CRM software modules extracted from ERP system, as shown in Fig. 3.

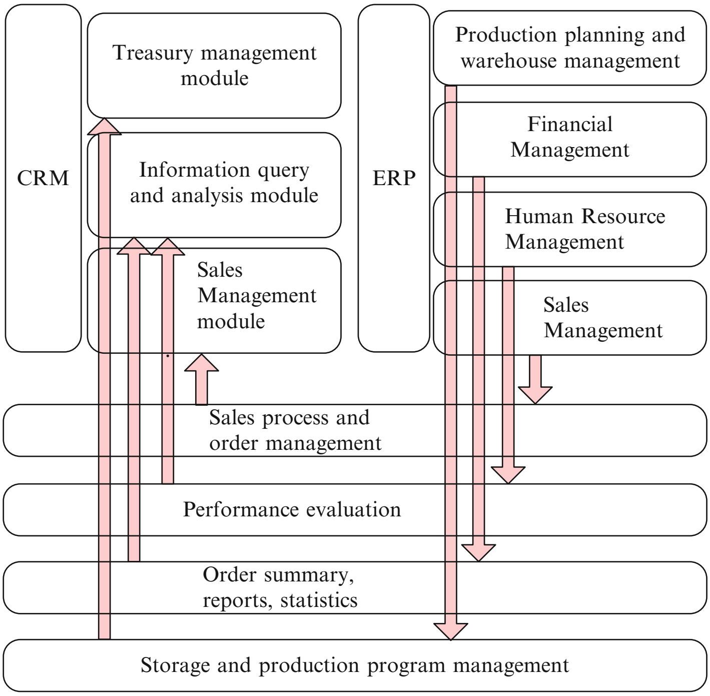

Fig. 3 Relationships between CRM and ERP

Other design issues: Selected development tools according to the requirements and modular design: The CRM software design of this article selects the popular programming language C#, It includes single inheritance, interfaces, almost the same syntax with Java, and the same process that compiled into intermediate code and Re-run, it also draws on the characteristics of the Delphi, directly integrated with COM (Component Object Model), it's safe, stable, it has powerful operability, elegant syntax style, features innovative in language, convenient Programming Oriented Component. The system architecture using C/S structure, it has the advantage of simple operation, easy management, high efficiency, small server-side pressure, high security and other advantages. Choose Visual Studio 2008 for programming tools. We select SQL SERVER2005 for database tools; it has the ease-of-use, scalability for distributed organizations, the data warehouse function for decision support, closely associated integration with a number of other server software, good value for money. The choices of the above tools are suitable in this case.

After conceptual design, convey the demand for the company's by the visual form through the thinking of the understanding and distinguish between the objective world via conception, judgment, reasoning, and argumentation. Build customer information table, product information table and any other forms that needed, establish the linkages between the form, According to the specific database management system, a variety of storage structures and access methods rely on the physical design measures of specific computer architecture, choose the most appropriate physical storage structures, access methods and access paths for specific application task.

4 Conclusions

Up to now, CRM has been paid much attention to the constantly ongoing exploration. This paper is for a technologically sophisticated, internal demand contradictions, functional requirements do not match with the existing CRM system software in the market, emerging small and medium-sized new materials enterprises, use the modular design approach, successful implement the software design by lot of detailed demand analysis at prophase. Its structure is simple, targeted, and full-featured; achieve the workflow management, in line with the current software development trends of integration design of CRM and ERP.

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Research on Human Factors Engineering of Ming-Style Furniture

De-hua Yu

Abstract Ming-style furniture belongs to Chinese traditional furniture, which refers to the simple and artistic furniture from late Ming dynasty to early Qing dynasty approximately. Ming-style furniture is the elite of Chinese traditional furniture, which is also doing well in human factors engineering, although theoretical research of human beings factors engineering lagged far behind in ancient China, until it was introduced into China. Ming-style furniture has sculptural form and vigorous curve, which is the result of the consideration of human factors engineering. Especially Ming-style chairs express comfort and consideration all over. Based on the study of Ming-style furniture, the practice of human factors engineering in Ming-style furniture is summarized, which is meaningful for the design of Chinese traditional furniture to develop ergonomics.

Keywords Chinese traditional furniture • Human factors engineering • Ming-style furniture • Ming and Qing furniture

1 Background

1.1 Human Factors Engineering

Human factors engineering is also called human engineering, human factors or ergonomics, the discipline of which was first specified by Poland scholars Jastrzebowski in 1857 [1]. He defined the goal of this new discipline as to explore human work and apply the results to enhance the working conditions. Although it was put

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forward in the mid nineteenth century, human factors engineering already existed as early as human beings come forth. Chinese ancient sage Confucius once said sharp tools make good work more than 2,000 years ago, which is also the concept of ergonomics. And it developed in the process of practice during the past 2,000 years in China. However, theoretical research of human factors engineering lagged far behind, until it was introduced into China [2].

Human factors engineering has wide application in many industrial and social fields, especially the environment interacting frequently with people, for example, the living environment of human beings [3]. Furniture design also has intimate relationship with human factors engineering.

Furniture design is an important part of industrial design or environment design, which is more related to human factors engineering [4]. Even in furniture advertisement and specifications, the term human factors engineering is frequently mentioned, and many manufactures set up special department to research how to make the furniture more comfortable with the help of ergonomics.

1.2 Ming-Style Furniture

Ming-style furniture belongs to Chinese traditional furniture, which refers to the simple and artistic furniture from late Ming dynasty to early Qing dynasty approximately [5]. The history of Chinese furniture could be traced back to Shang or Zhou Dynasty about more than 3,000 years ago. However, it was only until late Ming (1368–1644 AD) and early Qing Dynasty (1644–1919 AD) that Chinese furniture reached its golden age [6]. Differing in size, construction, materials, and decoration, Ming-style furniture refers to the common characteristic as follows [7]: simple and sculptural form with reserved decoration; accurate and fitting proportion with dynamic and vigorous curve; exquisite craftsmanship with precise mortise and tenon; solid wood with fine vein and patina. The definition of Ming-style furniture has broad sense and narrow sense. The broad sense means the furniture that follows the characteristics of Ming-style furniture, whenever it was made. The narrow sense of Ming-style furniture means the furniture that follows the characteristics of Ming-style furniture between the late Ming and early Qing periods. This paper prefers the narrow sense of Ming-style furniture.

People would feel comfortable whenever people sit in or just touch Ming-style furniture. For example, when one sits in a Ming-style chair, the soft cushion supports his buttock, and the S-shaped backrest fits the S-shaped curve of the spine properly. He could put his arms and hands on the armrest at ease, and also could put his feet on the footrest or stretch them freely. He could even give a stretch in the chair. The surface of the chair touches smooth and warm. All the vision, touch, sense exhibits dignity and poise [8].

2 Analysis

2.1 Study of Three Typical Ming-Style Chairs

2.1.1 Round-Backed Armchair

Round-backed armchair (Fig. 1) is a particular chair of Chinese traditional furniture by reason of his curved rest, which supports the back and arms at the same time.

When we sit in a round-backed armchair, there are three different ways to choose (Fig. 2). We can sit in the chair with our back and arms on the backrest and round back for relaxation freely, and the spine could be supported by the backrest. Or we

Fig. 1 Huanghuali round-backed armchair

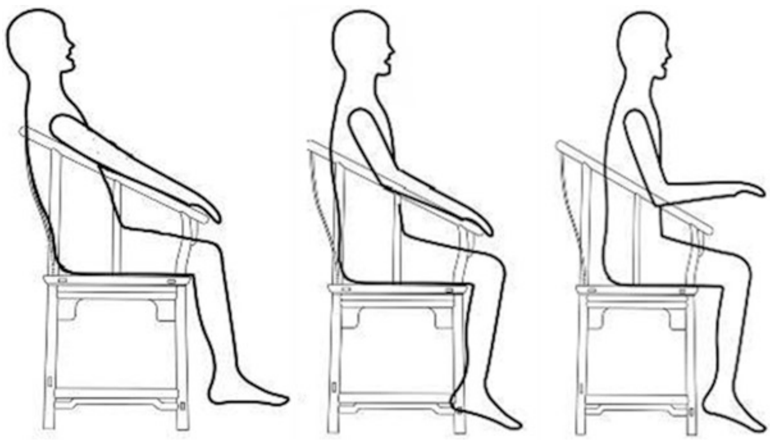

Fig. 2 Three different ways to sit in the round-backed armchair, dimension reference from 95 % men of human dimension of Chinese adults GB10000-88

Fig. 3 Sitting in the round-backed armchair

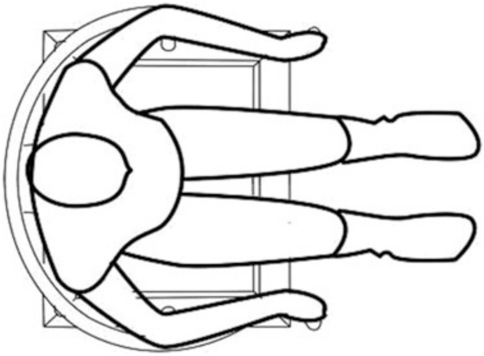

Fig. 4 Footstool

can sit in the centre of the chair, then the lumbar is supported by the backrest, and we could work at ease. Or just sit forward without the support of the round back when we are busy at work [9]. That means the round-backed armchair is not only a chair for leisure, but also a chair for work.

The front part of the round back is the armrest, which has also S-shaped curve. When we put our arms on the armrest, the arm protrudes from the shoulder slightly, then gets back and ends by the hand. The shape of the arm is similar with the S-shaped armrest, which supports the arms considerately and comfortably. The end of the armrest extends a little as the handgrip to support the hand, which also messages the hands gently (Fig. 3).

When people sit in the chair, their feet are mostly put on the floor directly [10], Hu. But the Chinese traditional chair has the special footrest to support the feet. Therefore most of the Ming-style chairs are a little taller than the ordinary chairs because of the footrest. People could put their feet on the footrest, or also on the floor to find the best comfortable poise. There is a particular category of Chinese traditional furniture called footstool, which is designed and made to support the feet. When people sit in the chair or bed, in front of which the footstool is placed to provide the place for the feet. Some footstools even have the round sticks on the surface to message the feet when people trundle the stick with their feet continually, which is useful for their health (Fig. 4). Not all the people but high officials or noble lords could use these kinds of furniture like the footstool.

Fig. 5 Zitan southern official's hat armchair

2.1.2 Southern Official's Hat Armchair

The official's hat chair is the specific category of Ming-style furniture, which could be divided into two categories: the yoke-backed armchair and the southern official's hat armchair. The name of yoke-backed armchair reflects the shape of the yoke back, which looks like an official's hat and implies the use by officials. The southern official's hat armchair doesn't have the yoke back, and there are no four protruding ends, which ends with rounded transition.

The seat of the chair is woven with soft cane matting, which supports the buttock softly. Nowadays people always complain that the seat of Ming-style furniture is hard, which already influences the comfort. Because the seat of the chair in the market nowadays is just the solid wood, or the cane matting is on the solid wood for decoration. Actually, the real Ming-style chair is not naked but decorated with mat or cushion. There are several ways to deal with the seat. In northern area of China, people choose the solid wood seat, which is nice and cool in summer, and people would add to the cushion on the seat for warm and soft in winter. In the southern area of China, people prefer the soft cane matting, which has the flexibility to support the buttock. The seat is designed considerately by ancient craftsmen to ensure the comfort and poise. But what a pity is that most of the details are ignored by people nowadays.

The Zitan southern official's hat armchair (Fig. 5) is one of the most beautiful chairs of Chinese traditional furniture, and also the most comfortable chair. What should be paid more attention to is that the zitan southern official's hat armchair has trapezoidal seat (Fig. 6), not the common square seat. The special trapezoidal seat provides wider space for people to move freely in the chair, which is also the warm consideration of ergonomics [11].

The armrest of the southern official's hat armchair separates from the backrest compared with the round-backed armchair. The armrests are generally of S-shape

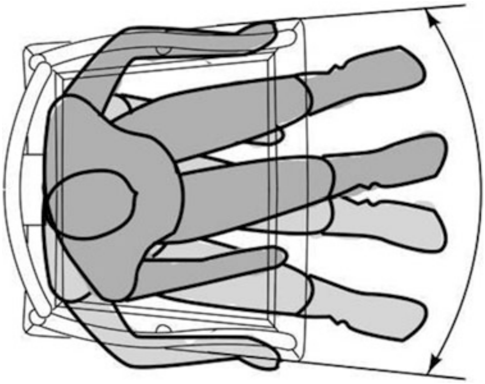

Fig. 6 The trapezoidal seat of the chair

according with the S-shaped arm and hand. People's arm and hand could extend on the armrest at ease, which is also the detail of the human factors engineering.

The backrest of the southern official's hat armrest is the common S-shape, while a small portion of the chairs have the C-shaped backrest. The backrest may be made from a solid piece of wood or comprised with several panels that are sometimes pierced or carved with decorative motifs. The curve of the backrest can give the spine appropriate and correct support, which helps the spine maintain an S-shaped curve similar to the spine's shape when standing. Different chairs have different curves, most of which support the spine well with the help of the other curves of the chair [12]. However, some chairs are not intended for relaxation like the ergonomic backrests of other traditional chairs, for example, the straight backrest of the rose chair, which has other intention.

2.1.3 Folding Chair

Folding chair is also called huchuang, which was introduced from the northwest minority called hu, and could trace from Han Dynasty. The folding chairs can be divided into round-back and square-back chairs. The folding chair is portable, which could be folded and transported anywhere you want. The seat of the folding chair must be soft woven cord that can be folded, which supports the buttock tenderly. That's also the detail of the human factors.

The folding chair also has footrest to support the feet. The footrest is emphasized compared with other kinds of Chinese traditional furniture. Some folding chairs have special footstools in front of them to help the comfort.

Huanghuali folding chair (Fig. 7) is the common round-back folding chair, which is decorated with reserved carving and metalwork ornaments. The C-shaped backrest is different from the S-shaped backrest of common Ming-style furniture. We know that the S-shaped backrest supports the S-shaped spine properly, which is more comfortable than the C-shaped and even the straight backrest like the rose chair [13] (Fig. 8).

Fig. 7 Huanghuali folding chair

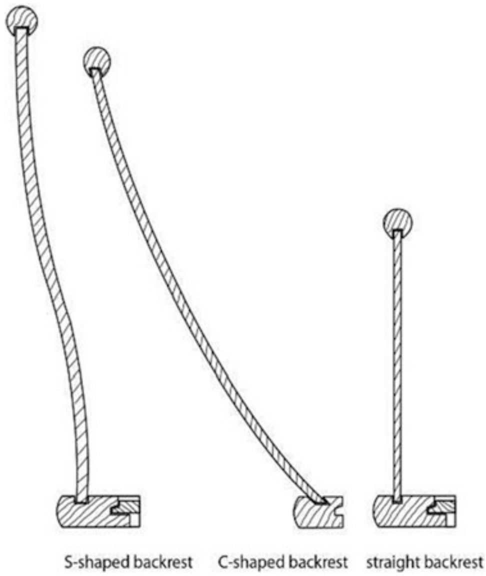

Fig. 8 S-shaped backrest, C-shaped backrest, straight backrest

2.2 Analysis of the Ming-Style Furniture

1. *Human factors engineering of Ming-style furniture*: Through the study of different kinds of Ming-style furniture, we discovered that the comfort of Ming-style furniture is the consideration of the human factors engineering, which people seemed to be aware of, although they didn't study the system information of ergonomics [14].
2. *Smooth and warm surface*: Furniture is the intimate friend of people, which is surround people, and close with people. When people use one chair, the touch is

important first and foremost. The surface of the chair is smooth and warm to the touch, even some solid wood get fine vein and patina, which give people with warm and comfortable feeling.

3. *Accurate and fitting proportion*: Ming-style furniture has the accurate and fitting proportion, and most of people who use it feel appropriate in size and scale. Although there were no standard anthropometric databases in ancient times, most of the furniture is close to the average scale range.
4. *Dynamic and graceful curves*: Ming-style furniture is the performance of multifarious curve, every part of which is curved gracefully and elegantly. Especially the parts that contacted with people closely are paid more attention to with the relevant curves. For example, the S-shaped backrest supports the S-shaped spine, and the curved armrest supports the arms.
5. *Exquisite and considerate detail*s: Details are vital for design and also the furniture. Exquisite and considerate details of Ming-style furniture help shape the furniture. For example, the soft cane seat and the solid wood seat with cushion give people more choices for comfort. And the smooth handgrip help message the hands tenderly.
6. *First the chair then the form*: A chair is first a chair then works of art. Ming-style furniture pays more attention to the function, and the chair is not only comfortable, but also used for hundreds of years. Based on the well function, the chair is decorated properly.

3 Conclusion

Human factors engineering had been in widely used in Ming-style furniture hundreds of years ago, although the concept of it was first put forward in mid nineteenth century. Ming-style furniture has exquisite form, exacting craftsmanship, strong mortise and tenon structure and the consideration of human factors engineering, which contributes the comfort and poise. Details about the human factors are omnipresent, including the smooth and warm surface, accurate and fitting proportion, dynamic and graceful curves, etc., all of which help Ming-style furniture reach its golden age [15].

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Decision Analysis for Closed-Loop Supply Chains with Manufacturing Cost Disruptions

Xiao-hua Han, Hai-yan Wu, and Bei Wang

Abstract This paper studies the decisions in closed-loop supply chain with manufacturing cost disruptions. We find that the optimal solutions in stable context are still robust when manufacturing cost disruptions are small. The optimal decisions are revised when manufacturing cost disruptions exceed the thresholds. Moreover, the decision maker in centralized context and manufacturer in decentralized context always prefer to change their decisions with disruptions, while the retailer in decentralized context only prefer to change when the manufacturing cost disruption is negative.

Keywords Closed-loop supply chain • Disruption • Game theory

1 Introduction

In the context of developing recycling and low-carbon economy, the important of closed-loop supply chain managements has been widely recognized by governments, researchers, and practitioners. As a big manufacturing country, many used products have been produced in China every year, which provide plenty of materials for developing closed-loop supply chains. Unfortunately, due to the low efficiency of operation, the enterprises that implement closed-loop supply chain managements cannot get sufficient and stable used products, and then not obtain profits. The low efficiency of operation is a serious impediment to the application and development of closed-loop supply chains in China.

The pricing is one of the important decisions, which is closely related to the efficiency of closed-loop supply chains. Therefore, many research efforts have been

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made to study pricing decisions facing closed-loop supply chain problems [1–9]. For example, Savaskan et al. studied the pricing decisions in bilateral monopoly closed-loop supply chains based on noncooperative game [1]. Savaskan et al. further studied pricing decisions in closed-loop supply chains with one monopoly manufacturer and two competing retailers [2]. Ferrer and Jayashankar studied pricing decisions in multicycle closed-loop supply chains with two different markets [3]. Based on above studies, Ferrer and Jayashankar continued to discuss the pricing decisions of new and remanufactured products with considering the less recycling numbers contracts [4]. Atasu et al. studied pricing decisions with considering the influence of manufacturer's competition, green consumer groups, and market growth [5]. Bao et al. investigated pricing decisions in bilateral monopoly closed-loop supply chains with the restricted number of recycling products and difference between new and used products [6].

Although many advances have been made on pricing decision in closed-loop supply chains, the researches on pricing decisions with disrupted situations are rarely found in literature. However, decision makers often face unstable situations in the closed-loop supply chains. Generally, disruptive events will significantly influence the performance of supply chains. Moreover, there are plenty of evidences to suggest that production costs are relatively easier to disrupt in closed-loop supply chains.

Disruption management of supply chains has gained much attention among researchers and practitioners [10–19]. For instance, Qi et al. studied pricing and coordination decisions in a one-supplier–one-retailer supply chain with demand disruptions [10]. Xiao et al. then extended disruption management of the supply chain with multiple competing retailers [11]. Xiao and Yu developed an indirect evolutionary game model to study evolutionarily stable strategies of retailers on market target selection with demand and raw material supply disruptions [12]. Yu et al. studied how to handle disruptions in the supply chain under wholesale price contract [13]. Xiao and Qi investigated how to coordinate a supply chain with multiple competing retailers using game theory when the production cost was disrupted [14]. Chen and Xiao designed linear quantity discount and wholesale price contracts in a supply chain with production cost and demand disruptions [15]. Zhang et al. investigated how to coordinate the supply chain with demand disruptions by revenue-sharing contracts [16]. Huang et al. studied pricing and production decisions in dual-channel supply chains when production costs are disrupted [17].

The above literatures have found many important insights in disruption management of supply chains. However, most of them only concerned about decisions in open-loop supply chains, but closed-loop supply chains. Closed-loop supply chains are more complex, which have characteristics of not only forward logistics but also reverse logistics. Consequently, manufacturing costs and other related parameters are more easily disrupted in closed-loop supply chains.

In this research, we analyze decisions in bilateral monopoly closed-loop supply chains with manufacturing cost disruptions. We find the optimal decisions in stable contexts have some robustness. The optimal decisions are revised only when manufacturing cost disruptions exceeds some thresholds. The centralized decision maker and manufacturer in decentralized decision making always prefer to change their decisions when the absolute value of disruptions are larger than the threshold. However, the retailer in decentralized decision making prefer to change his decision only when manufacturing cost disruptions are negative.

The rest of this paper is organized as follows. After introducing the model assumptions and notations in Sect. 2, the decision models without disruptions are described in Sect. 3. Decision models with disruptions are developed in Sect. 4. Section 5 presents some numerical examples. Conclusions and extensions are provided in Sect. 6.

2 Model Assumptions and Notations

We mainly discuss decisions in a closed-loop supply chain with one dominant manufacturer and one retailer. The manufacturer is in charge of re/manufacturing new products and collecting used products, and the retailer is responsible to distribute new products.

Before presenting models we introduce the following notation. C_m, unit cost of manufacturing a new product; C_r, unit cost of remanufacturing a new product; Δ, unit cost savings from remanufacturing a product, that is $\Delta = C_m - C_r$; u_1, marginal disposal cost; u_2, the marginal underage cost; $q(p) = \phi - \beta p$, market demand with p represents the retailer's price, and ϕ and β are positive parameters; τ, return rate of used products, and $\tau = \sqrt{I/B}$, where I stands for fixed investments in collection activities and B a scaling parameter; Π, profit function; $(\ )_C$, results from centralized decisions; $(\ )_M$, results from the manufacturer; $(\ )_R$, results from the retailer; $(\ )^U$, results from unchanged decisions with disruptions; $(\ )^*$, results from the optimal solutions.

In order to simplify research process, we make the following assumptions based on existing research.

Assumption 1 Manufacturing and remanufacturing products are identical to customers and can be sold in the same market with the same price.

Assumption 2 We let the sum of used product's collection price and transportation cost is zero since it is exogenous and does not affect the results.

Assumption 3 Manufacturers and retailers make decisions in the game of complete information.

Assumption 4 We study the pricing decisions in a two-period closed-loop supply chain. In the first period, the manufacturer purchases some raw materials due to a long lead time, and then products new products in the second period. The preliminary production plan is made based on the estimated manufacturing cost C_m in the first period, and the actual production plan is made based on real production cost $C_m + \delta$, where the manufacturing cost disruption is δ in the second period.

3 Decision Models Without Disruptions

In this section we present the centralized and decentralized decision models as baseline, which are used to study the impact of manufacturing cost disruptions on decisions.

3.1 Centralized Decision Model

In a centralized closed-loop supply chain, the decision maker makes her decision based on maximizing the total profits of closed-loop supply chain. Based on our assumptions, the centralized pricing model is determined by

$$\max_{p,\tau} \Pi_{\mathrm{C}} = (\phi - \beta p)\,(p - \mathrm{C_m} + \Delta\tau) - \mathrm{B}\tau^2$$

According to the first-order optimal conditions, the optimal solutions of the above model are given by

$$p_{\mathrm{C}}{}^{*} = \frac{2\mathrm{B}\,(\phi + \beta \mathrm{C_m}) - \beta\phi\Delta^2}{\beta\,(4\mathrm{B} - \beta\Delta^2)} \tag{1}$$

$$\tau_{\mathrm{C}}{}^{*} = \frac{\Delta\,(\phi - \beta \mathrm{C_m})}{4\mathrm{B} - \beta\Delta^2} \tag{2}$$

$$q_{\mathrm{C}}{}^{*} = \frac{2\mathrm{B}\,(\phi - \beta \mathrm{C_m})}{4\mathrm{B} - \beta\Delta^2} \tag{3}$$

$$\prod\nolimits_{\mathrm{C}}^{*} = \frac{\mathrm{B}(\phi - \beta \mathrm{C_m})^2}{\beta\,(4\mathrm{B} - \beta\Delta^2)} \tag{4}$$

3.2 Decentralized Decision Model

As a Stackelberg leader, the manufacturer first decides ϖ, τ, and the retailer then decides p. Thus, the decentralized pricing model can be given by

$$\max_{\varpi,\tau} \Pi_{\mathrm{M}} = (\phi - \beta p)\,(\varpi - \mathrm{C_m} + \Delta\tau) - \mathrm{B}\tau^2$$

$$\text{s.t.}\, p \in \operatorname{argmax} \Pi_{\mathrm{R}} = (\phi - \beta p)\,(p - \varpi)$$

By using backward induction and the first order condition, the optimal solutions are given by

$$\varpi^* = \frac{\left(4\mathrm{B} - \beta\Delta^2\right)\phi + 4\mathrm{B}\beta\mathrm{C_m}}{\beta\left(8\mathrm{B} - \beta\Delta^2\right)} \tag{5}$$

$$p^* = \frac{\left(6\mathrm{B} - \beta\Delta^2\right)\phi + 2\beta\mathrm{B}\mathrm{C_m}}{\beta\left(8\mathrm{B} - \beta\Delta^2\right)} \tag{6}$$

$$\tau^* = \frac{\Delta\left(\phi - \beta\mathrm{C_m}\right)}{8\mathrm{B} - \beta\Delta^2} \tag{7}$$

$$q^* = \frac{2\mathrm{B}\left(\phi - \beta\mathrm{C_m}\right)}{8\mathrm{B} - \beta\Delta^2} \tag{8}$$

$$\Pi_{\mathrm{M}}{}^* = \frac{\mathrm{B}(\phi - \beta\mathrm{C_m})^2}{\beta\left(8\mathrm{B} - \beta\Delta^2\right)} \tag{9}$$

$$\Pi_{\mathrm{R}}{}^* = \frac{4\mathrm{B}^2(\phi - \beta\mathrm{C_m})^2}{\beta(8\mathrm{B} - \beta\Delta^2)^2} \tag{10}$$

4 Decision Models with Cost Disruptions

In this section, we discuss the decision models with manufacturing cost disruptions. If the manufacturing cost disruption $\delta > 0$, the actual manufacturing cost is larger than estimated. In this context, the decision maker will increase his pricing, and there will be disposal costs for unsold products. If the manufacturing cost disruption $\delta < 0$, the actual manufacturing cost is smaller than estimated. In this context, the decision maker will decrease his pricing, and there will be underage costs for unmet demand.

4.1 Centralized Decision Model with Disruptions

The centralized decision model with disruptions $\delta > 0$ is given by

$$\begin{aligned}\max_{\tilde{p},\tilde{\tau}} \tilde{\Pi}_{\mathrm{C}} &= (\phi - \beta\tilde{p})\,(\tilde{p} - (\mathrm{C_m} + \delta) + \Delta\tilde{\tau}) \\ &\quad - \mathrm{B}\tilde{\tau}^2 - \mu_1\left(\frac{2\mathrm{B}\left(\phi - \beta\mathrm{C_m}\right)}{4\mathrm{B} - \beta\Delta^2} - (\phi - \beta\tilde{p})\right)\end{aligned}$$

The centralized decision model with disruptions $\delta < 0$ is given by

$$\max_{\tilde{p},\tilde{\tau}} \tilde{\Pi}^{\mathrm{C}} = (\phi - \beta\tilde{p})\,(\tilde{p} - (\mathrm{C_m} + \delta) + \Delta\tilde{\tau}) - \mathrm{B}\tilde{\tau}^2 - \mu_2\left((\phi - \beta\tilde{p}) - \frac{2\mathrm{B}\,(\phi - \beta\mathrm{C_m})}{4\mathrm{B} - \beta\Delta^2}\right)$$

We can derive the optimal solutions by the first-order optimal conditions. The optimal solutions are given by

$$\tilde{p}_{\mathrm{C}}^{*} = \begin{cases} \dfrac{2\mathrm{B}\,(\phi + \beta\mathrm{C_m} + \beta\delta - \beta\mu_1) - \beta\phi\Delta^2}{\beta\,(4\mathrm{B} - \beta\Delta^2)} & \delta > \mu_1 \\ \dfrac{2\mathrm{B}\,(\phi + \beta\,(\mathrm{C_m} + \delta + \mu_2)) - \beta\phi\Delta^2}{\beta\,(4\mathrm{B} - \beta\Delta^2)} & \delta < -\mu_2 \end{cases} \tag{11}$$

$$\tilde{\tau}_{\mathrm{C}}^{*} = \begin{cases} \dfrac{\Delta\,(\phi - \beta\mathrm{C_m} + \beta\mu_1 - \beta\delta)}{4\mathrm{B} - \beta\Delta^2} & \delta > \mu_1 \\ \dfrac{\Delta\,(\phi - \beta\,(\mathrm{C_m} + \mu_2 + \delta))}{4\mathrm{B} - \beta\Delta^2} & \delta < -\mu_2 \end{cases} \tag{12}$$

$$\tilde{q}_{\mathrm{C}}^{*} = \begin{cases} \dfrac{2\mathrm{B}\,(\phi - \beta\mathrm{C_m} + \beta\mu_1 - \beta\delta)}{4\mathrm{B} - \beta\Delta^2} & \delta > \mu_1 \\ \dfrac{2\mathrm{B}\,(\phi - \beta\,(\mathrm{C_m} + \mu_2 + \delta))}{4\mathrm{B} - \beta\Delta^2} & \delta < -\mu_2 \end{cases} \tag{13}$$

$$\tilde{\Pi}_{\mathrm{C}}^{*} = \begin{cases} \dfrac{\mathrm{B}\left((\phi - \beta\mathrm{C_m} - \beta\delta)^2 - 2\beta^2\delta\mu_1 + \beta^2{\mu_1}^2\right)}{\beta\,(4\mathrm{B} - \beta\Delta^2)} & \delta > \mu_1 \\ \prod_{\mathrm{C}}^{\mathrm{U}} = \dfrac{\mathrm{B}\,(\phi - \beta\mathrm{C_m})\,(\phi - \beta\mathrm{C_m} - 2\beta\delta)}{\beta\,(4\mathrm{B} - \beta\Delta^2)} & -\mu_2 \le \delta \le \mu_1 \\ \dfrac{\mathrm{B}\left((\phi - \beta\mathrm{C_m} - \beta\delta)^2 + \beta^2\mu_2\,(2\delta + \mu_2)\right)}{\beta\,(4\mathrm{B} - \beta\Delta^2)} & \delta < -\mu_2 \end{cases} \tag{14}$$

If $-u_2 \le \delta \le u_1$, the optimal solutions are same with the optimal in centralized model without disruption except the profits.

4.2 *Decentralized Pricing Model with Disruptions*

The decentralized decision model with disruptions $\delta > 0$ can be given by

$$\max_{\tilde{\varpi},\tilde{\tau}} \tilde{\Pi}_{\mathrm{M}} = (\phi - \beta \tilde{p})\,(\tilde{\varpi} - (\mathrm{C_m} + \delta) + \Delta \tilde{\tau}) - \mathrm{B}\tilde{\tau}^2$$
$$- \mu_1 \left(\frac{2\mathrm{B}\,(\phi - \beta \mathrm{C_m})}{8\mathrm{B} - \beta\Delta^2} - (\phi - \beta \tilde{p}) \right)$$
$$\text{s.t.}\,\tilde{p} \in \operatorname{argmax} \tilde{\Pi}_{\mathrm{R}} = (\phi - \beta \tilde{p})\,(\tilde{p} - \tilde{\varpi})$$

The decentralized decision model with disruptions $\delta < 0$ can be given by

$$\max_{\tilde{\varpi},\tilde{\tau}} \tilde{\Pi}_{\mathrm{M}} = (\phi - \beta \tilde{p})\,(\tilde{\varpi} - (\mathrm{C_m} + \delta) + \Delta \tilde{\tau}) - \mathrm{B}\tilde{\tau}^2$$
$$- \mu_2 \left((\phi - \beta \tilde{p}) - \frac{2\mathrm{B}\,(\phi - \beta \mathrm{C_m})}{8\mathrm{B} - \beta\Delta^2} \right)$$
$$\text{s.t.}\,\tilde{p} \in \operatorname{argmax} \tilde{\Pi}_{\mathrm{R}} = (\phi - \beta \tilde{p})\,(\tilde{p} - \tilde{\varpi})$$

We can get the optimal solutions by using backward induction and the first order condition. The optimal solutions can be given by

$$\tilde{\varpi}^* = \begin{cases} \dfrac{\left(4\mathrm{B} - \beta\Delta^2\right)\phi + 4\mathrm{B}\beta\,(\mathrm{C_m} + \delta - \mu_1)}{\beta\,(8\mathrm{B} - \beta\Delta^2)} & \delta > \mu_1 \\[2ex] \dfrac{\left(4\mathrm{B} - \beta\Delta^2\right)\phi + 4\mathrm{B}\beta\,(\mathrm{C_m} + \delta + \mu_2)}{\beta\,(8\mathrm{B} - \beta\Delta^2)} & \delta < -\mu_2 \end{cases} \tag{15}$$

$$\tilde{p}^* = \begin{cases} \dfrac{\left(6\mathrm{B} - \beta\Delta^2\right)\phi + 2\beta\mathrm{B}\,(\mathrm{C_m} + \delta - \mu_1)}{\beta\,(8\mathrm{B} - \beta\Delta^2)} & \delta > \mu_1 \\[2ex] \dfrac{\left(6\mathrm{B} - \beta\Delta^2\right)\phi + 2\beta\mathrm{B}\,(\mathrm{C_m} + \delta + \mu_2)}{\beta\,(8\mathrm{B} - \beta\Delta^2)} & \delta < -\mu_2 \end{cases} \tag{16}$$

$$\tilde{\tau}^* = \begin{cases} \dfrac{\Delta\,(\phi - \beta\,(\mathrm{C_m} + \delta - \mu_1))}{8\mathrm{B} - \beta\Delta^2} & \delta > \mu_1 \\[2ex] \dfrac{\Delta\,(\phi - \beta\,(\mathrm{C_m} + \delta + \mu_2))}{8\mathrm{B} - \beta\Delta^2} & \delta < -\mu_2 \end{cases} \tag{17}$$

$$\tilde{q}^* = \begin{cases} \dfrac{2\mathrm{B}\,(\phi - \beta\,(\mathrm{C_m} + \delta - \mu_1))}{8\mathrm{B} - \beta\Delta^2} & \delta > \mu_1 \\[2ex] \dfrac{2\mathrm{B}\,(\phi - \beta\,(\mathrm{C_m} + \delta + \mu_2))}{8\mathrm{B} - \beta\Delta^2} & \delta < -\mu_2 \end{cases} \tag{18}$$

$$\tilde{\Pi}_M^* = \begin{cases} \dfrac{B(\phi - \beta\,(C_m + \delta))^2 - \beta^2\mu_1\,(2\delta - \mu_1)\Big)}{\beta\,(8B - \beta\Delta^2)} & \delta > \mu_1 \\ \dfrac{B\,(\phi - \beta C_m)\,(\phi - \beta C_m - 2\beta\delta)}{\beta\,(8B - \beta\Delta^2)} & -\mu_2 \le \delta \le \mu_1 \\ \dfrac{B\Big((\phi - \beta\,(C_m + \delta))^2 + \beta^2\mu_2\,(2\delta + \mu_2)\Big)}{\beta\,(8B - \beta\Delta^2)} & \delta < -\mu_2 \end{cases} \tag{19}$$

$$\tilde{\Pi}_R^* = \begin{cases} \dfrac{4B^2(\phi - \beta\,(C_m + \delta - \mu_1))^2}{\beta(8B - \beta\Delta^2)^2} & \delta > \mu_1 \\ \dfrac{4B^2(\phi - \beta C_m)^2}{\beta(8B - \beta\Delta^2)^2} & -\mu_2 \le \delta \le \mu_1 \\ \dfrac{4B^2(\phi - \beta\,(C_m + \delta + \mu_2))^2}{\beta(8B - \beta\Delta^2)^2} & \delta < -\mu_2 \end{cases} \tag{20}$$

If $-u_2 \le \delta \le u_1$ the optimal solutions are same with the optimal in decentralized model without disruption except the profits.

We can get the following propositions form comparing those solutions in different contexts.

Proposition 1 *The decisions in closed-loop supply chains have some robustness* $(-u_2 \le \delta \le u_1)$ *with manufacturing cost disruptions in the both centralized and decentralized situations.*

That is, decision makers will retain their optimal solutions of decision models without disruptions when the manufacturing cost disruption is small $(-u_2 \le \delta \le u_1)$.

Proposition 2 *When* $\delta > \mu_1$*, the market pricing is increased, while return ratio and quantity are decreased with disruptions; when* $\delta \le -\mu_2$*, the market pricing is decreased, while return ratio and quantity are increased with disruptions.*

Proposition 3 *The decision maker in centralized closed-loop supply chain prefers to change her decisions when manufacturing cost is disrupted.*

Proposition 4 *The manufacturer in decentralized closed-loop supply chain prefers to change her decisions, while the retailer only prefer to change his decisions when* $\delta \le -\mu_2$.

5 Numerical Analysis

In order to depict solutions more clearly, we make some numerical analyses in this section. We let $B = 100$, $\phi = 150$ $\beta = 4$, $C_m = 10$, $\Delta = 2$, $\mu_1 = \mu_2 = 2$, $-8 \le \delta \le 8$. The detailed decisions solutions are provided in Figs. 1, 2, 3, 4, and 5.

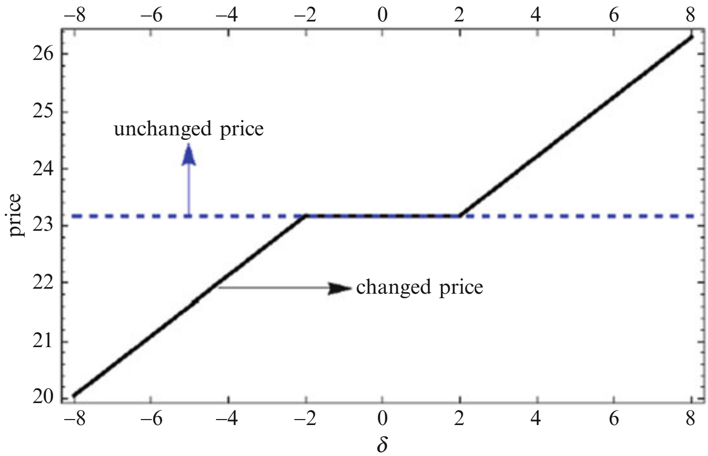

Fig. 1 Pricing in centralized model with disruptions

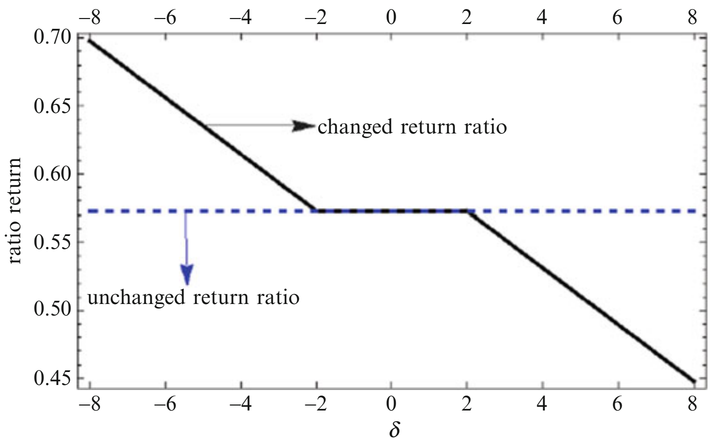

Fig. 2 Return rates in centralized model with disruptions

From Figs. 1, 2, 3, 4, and 5, we find that decisions have some robustness with manufacturing cost disruptions in the both centralized and decentralized situations. The market pricing is increased, while return ratio and quantity are decreased with disruptions when $\delta > u_1$; market pricing is decreased, while return ratio and quantity are increased with the absolute value of disruptions when $\delta < -u_2$. For the larger profits, decision maker in centralized context prefer to change her decisions with disruptions. The manufacturer in decentralized context also prefer to change her decisions, while the retailer only prefer to change his decisions when $\delta < -u_2$. Those are consistent with Proposition 1–4.

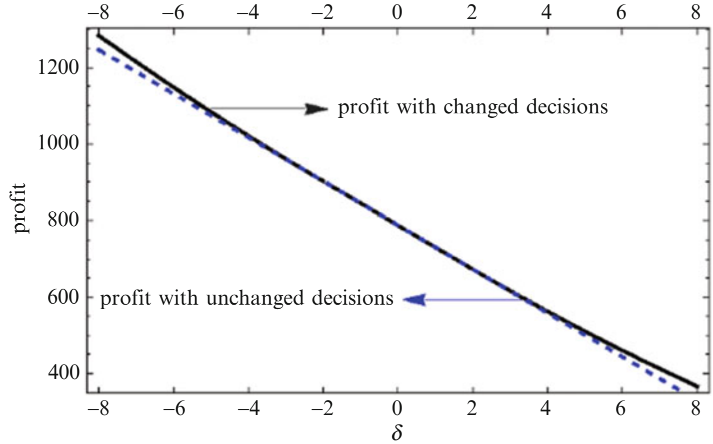

Fig. 3 Profits in centralized model with disruptions

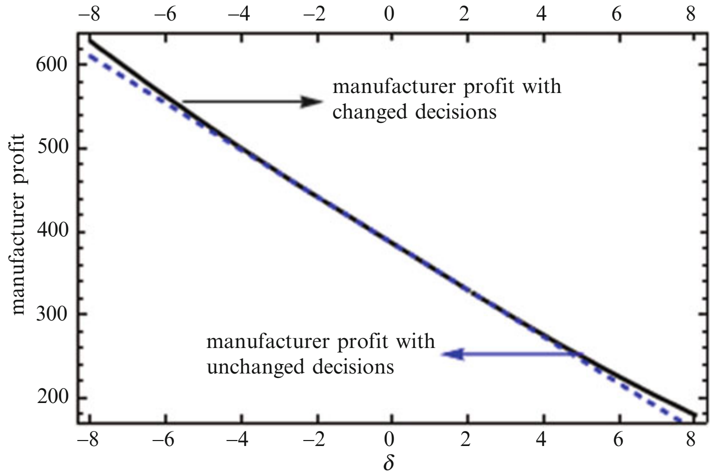

Fig. 4 Manufacturer profits in decentralized model with disruptions

6 Conclusion

In this paper, we study decision models of closed-loop supply chains with manufacturing cost disruptions. We find the optimal decisions in stable contexts have some robustness. The optimal decisions are revised only when manufacturing cost disruptions exceeds the thresholds. The centralized decision maker and manufacturer in decentralized decision making always prefer to change their decisions when disruptions exceed the threshold. However, the retailer in decentralized decision making change his decision only when manufacturing cost disruptions are negative.

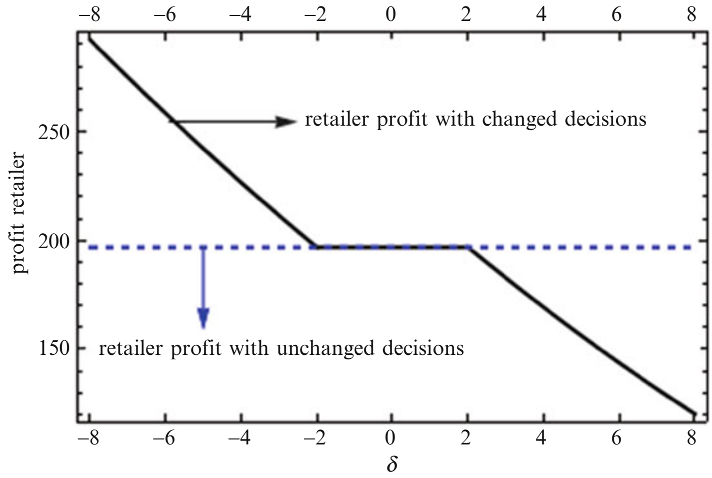

Fig. 5 Retailer profits in decentralized model with disruptions

This paper makes some contributions to the literature. However, we just consider very simple channel structure. How about decision models when there are multiple manufacturers or retailers? Those questions are our further research.

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Study on the Transfer and Integration of Production Factors in Industry Transfer

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Abstract In the process of industry transfer, the aggregation of production factors is not the simple centralization in space, but a process of creative and organic integration. First, the mechanisms of production factors transfer and integration are analyzed. We point out that market mechanisms promote the free flow of production factors and the essence of production factors integration is that it is an integrated process of innovation. Then we study the development path of production factors integration. In accordance with the order of time evolution, the path mainly include three stages, i.e., the primary aggregation of factors, the moderate centralization of organizations, and the high level integration of industrial factors. Based on the above analysis, we present an example of Chery Automobile Company, and the transfer and integration of car industry factors are analyzed. Finally, conclusions are drawn and policy suggestions are given.

Keywords Industry transfer • Production factors • Transfer and integration

1 Introduction

Globalization has become an important phenomenon in the development of world economy since 1990s. One of the key characteristics of globalization is the flow of production factors, including commodities, services, capitals, information, and ideas, etc., even including related industries, in the worldwide. The aim of the flow is to achieve the optimal allocation of production factors.

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The flow of production factors in the international scope does not mean the balanced allocation of production resources among all the countries in the world. Conversely, the actual performance of the flow of production factors is the occurrence of industry transfer and the form of regional economy clusters. Moreover, the clustering of production factors and industries is not only the simple moving of production means, such as assets, equipment and tools in spaces, but also the penetration of entrepreneurs' qualities, innovative ideas, technical levels, management levels, high-quality labor force, and the cooperation with external markets. All of these factors combined with the natural resources and cheap labor force merge creatively and integrate organically. The flow of production factors can bring a large number of innovative elements to the undertaking regions, and finally form the industrial clusters after the clustering and integration of creative elements [1].

Production factor is a general term of all the economic resources utilized in the production and business activities, usually including the capital, labor force, technology, land resources and economic information, etc. [2]. It has demonstrated that the transfer of production factors is an indispensable part of the regional economy development, and other production factors always flow among different regions besides natural resources such as land.

In this paper, we will focus on the mechanisms and development path of the transfer and integration of production factors. In order to study the mechanisms and paths of production factors transfer and integration, three basic questions will be answered in this paper: Why flow, how to flow and where to flow?

2 Mechanisms of Production Factors Transfer and Integration

2.1 Market Mechanisms Promote the Free Flow of Production Factors

The fundamental reason of production factors transfer is the differences of production factors in different regions, i.e., the absolute price differences brought by the differences of relative scarcity and the changing rate of factors' scarcity in different regions. One of the key influencing factors which promote the flow of production factors from low-price and low-reward areas to high-price and high-reward areas is the difference between the actual price and the marginal rate of return. That is to say, driven by market mechanisms, production resources and factors flow to the regions where they can obtain the best benefits [3].

Generally, the flow of production factors among different regions is dominated by three laws as shown in Fig. 1. First, they move to regions with the largest demand, where the scarcity of production factors is also greatest, and the supply and demand

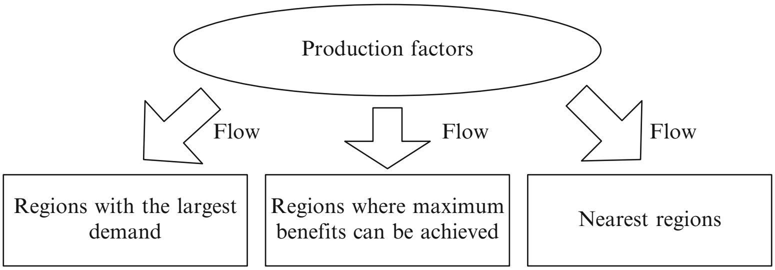

Fig. 1 The flow of production factors

contradiction is also biggest. Hence, the production factors of other regions are easy to be attracted. Second, they move to regions where maximum benefits can be achieved. There is a clear trend in the flow process of production factors, that is, the trend of pursuing benefits maximization. The benefits are comprehensive benefits, including economic and non-economic benefits. Third, they flow to the nearest regions, i.e. they follow the principle of proximity. The dissemination of information is more rapid and more complete if the distance is shorter. Hence, the flow of production factors is more convenient and the cost is lower.

2.2 The Essence of the Production Factors Aggregation Is an Integrated Process of Innovation

Integration is a process of innovative integration in which various factors are built and creative thinking is injected. Integration is not a simple combination process of many factors, but a process of reasonable, optimal and complementary selection, and making the integrated structure an optimal and organic entirety.

The idea of integrated innovation is first proposed by Schumpeter in 1912 in his book of "*Theory of Economic Development*" [4]. He added the element of innovative to the process of production factors integration and pointed out that, innovation is a process to "establish a new production function". Regroup the production factors and production conditions by introducing new products, new technology, opening up new markets and re-organization of industries. The rapid development of economy and society can be achieved by constant optimization and combination of these factors [5].

In the process of industry transfer, the clustering of production factors is not the simply gather and possess of external factors, but cooperation, creation of synergies, introducing innovative elements, and finally increasing the value of production factors. Hence, the essence of the integration of production factors is a process of integrated innovation.

3 Development Path of Production Factors Transfer and Integration

The practice of industry transfer has demonstrated that the transfer and integration of production factors in the process of industry transfer mainly go through a three-stage process, i.e. "primary aggregation of factors – moderate centralization of organizations – high degree integration of industrial elements". The development path of production factors transfer and integration is specifically shown in Fig. 2.

3.1 Industrial Factor Flow and Primary Aggregation Formation Driven by Market Mechanisms

Driven by market mechanisms, the aggregation of production factors in a certain region has some fortuity. It may because the settlement of an enterprise, the existence of an educational institution, the introduction of certain types of key talent or the promotion of local government. Also, the types of industrial factors aggregated are varied, and it may be natural resources, capitals, knowledge, technology or certain types of entrepreneurs [6]. The elements which may play a key role in regional economy development are always scarce high-level resources, such as key talents, key techniques, etc. These elements are always difficult to obtain, and they do not depend on the initial state. These elements need sustained investment and cultivation, i.e., these elements need to be created, thereby obtain the advanced elements with core competitiveness.

3.2 Moderate Centralization of Production Factors and Formation of Robust Integration Platforms

The integration of production factors is not the simply gather of factors, but an organic aggregation process. There will be synergistic effects brought by aggregated

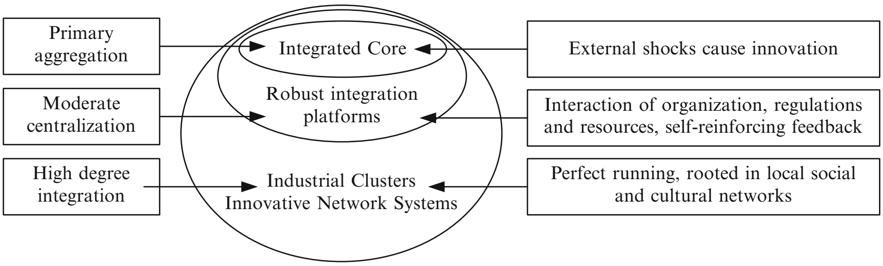

Fig. 2 The path diagram of production factors transfer and integration

factors, such as capital, technology, labor-force, natural resources and entrepreneur, etc. to the development of aggregates. Finally, the aggregates will become an organization with strong technology spillovers and self-enhancements, i.e. the aggregates become the integrated core.

The integrated core may attract industrial factors constantly and produce a higher level of agglomeration activities, i.e. the process of moderate centralization. The focuses of this stage are the division of work between enterprises and the formation of supply chain linkages among upstream and downstream enterprises. The industrial factors spread to complex network systems with logistics, information flow and business flow from the integrated core. Production factors gather to related industries, the scale of industries is expanded, and the competitiveness of industries is enhanced, therefore, the robust integration platforms are formed.

There are two types of robust integration platforms, visible and invisible platforms. Visible platforms are zones within an industrial area, such as Economic Development Zone, Export Processing Zone, and High-tech Development Zone, etc. Invisible platforms are the people, mechanisms or systems which can promote the connection and interaction of enterprises, governments and societies. Hence, the integration in this stage is no longer fortuitous, and this stage is a process of rational choice of production factors and organizations, also the result driven by market mechanism.

3.3 High Degree Integration of Industrial Factors and the Formation of Innovation Network Systems

The robust integration platform will produce integrated magnetic field, and then produce the support force, which will promote the reduction of transaction costs and the increase of value. First, through the restructuring and innovation of the industry cluster, supply chain alliances and other forms of industrial organization, the gathering of robust resources magnetic field will be realized, which will increase the efficiency of economic operation and reduce operating costs and improve industrial efficiency. Second, the robust integration platform will also promote the value chain extension, increase the scale of economy, and internalize external benefits, with a new source of value created. During this period, integrated production system is rooted in local social and cultural networks successfully. At the same time, industrial clusters innovation network systems with innovative features and some competitive advantages formed. Industrial clusters innovation network contains a formal cooperative network and informal cooperation networks within the cluster.

The system owns the function of organizing activities of clusters innovation, and it is of openness, innovation, network, cooperation, and it facilitates the flow of knowledge in order to reduce the operating costs in the system. Besides, it enables the system to a steady stream of maintaining vitality through the integration of different knowledge.

4 Case Study

We will analysis the process of production factors transfer and aggregation as follows based a typical case – the development of Chery Automobile Company.

Chery is an important force in the development of China's national automobile industry and a typical representative of independent innovation in the automotive industry. The process that Chery established and developed in Wuhu is a process that industrial factors transfer, gathering, integration and development.

Prior to the establishment of the Chery Automobile Company, there were no comparative advantages, such as talents, technology, management, capital and other elements, that related to car manufacturing in Wuhu. After Wuhu Chery Automobile Company developed through the introduction of these scarce resources from other regions, Wuhu attracted a large number of automobile industry supporting enterprise group to move there and form a unique automotive industry cluster by integrating robust platforms, extending the industry value chain, increasing economies of scale and reducing transaction costs [7, 8].

4.1 Chery Was Born in Wuhu, with a Certain Contingency

The Chery Automobile early comes from a car project of Wuhu municipal government. After the economic overheating period from 1992 to 1993, the idea of developing automotive industry gave birth in Wuhu. The initial plan is to cooperate with FAW, but it failed for many kinds of reasons. Wuhu municipal government leaders at that time took over a production line of Ford engine in the United Kingdom when they were investigating the automotive industry in Europe. Then a car project began. One of the major incentives that Chery was born in Wuhu is that it was driven by local government [9]. The government's long-term strategic vision has played an important role for the car industry cluster development, and the occasional opportunity promoted the development of the region-specific industry clusters.

4.2 The Key Factor of Chery' Success

After having the idea of doing car project, the personnel issues were proposed on the agenda. It was difficult to find the talents to participate the car project since the economy of Wuhu City is backwardness. The delegation of Wuhu became acquainted with Yin Tongyao when they were visiting the FAW. At that time, Yin Tongyao had worked in FAW for more than 12 years, and he is a talent in the automotive sector, and he was invited to preside over the car project by Wuhu municipal government. When he went to Wuhu, he also invited his colleagues to Chery [10].

The practice of Chery has demonstrated that the introduction of key personnel and core team, as well as the ensuing technology research has played crucial roles in the development of Chery.

4.3 The Key Factor for Chery to Maintain a Sustained Competitiveness

Since the establishment of Chery, its mission is to build China's own brand, its goal is to revitalize the national auto industry [11]. Just supported by this belief, Chery has a collection of excellent engineers and management personnel from different places to work for the common goal. Now each employee in Chery has a clear goal and mission. In addition, the effective learning mechanism of Chery is one of the key factors to realize its efficiency and core competitiveness. There are two parts, including the open learning system and the control of system knowledge and critical nodes.

5 Conclusion

Experiences and inspirations in the following three aspects can be drawn from the above theoretical analysis and case study for less developed areas to undertake industrial transfer. First, implement of the talent strategy to strengthen the ability of grasping historical opportunities. The talent is scarce senior elements, which will play a crucial role in both grasping historical opportunities and integrating other production factors. Second, strengthen the construction of independent innovation systems, and form stable platforms for the agglomeration of advantages. Enhance the ability of independent innovation of industrial clusters is an effective way to maintain a sustainable competitive advantage of industrial clusters and prevent cluster toward recession. Third, pay attention to the construction of hard and soft infrastructure, and improve the depth and breadth of factors integration. Infrastructure is the basic condition for the development of a variety of industries, and the material carrier for the operation of industrial factors integration mechanism.

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Agglomeration and Specialization of Innovative Industry and Its Productivity Growth—Empirical Study Based on the Aerospace Industry in the Mainland of China

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Abstract Issues about agglomeration and specialization of innovative industry have attracted more and more attention. This paper, taking the aerospace industry as the subject, with the panel data regression method, and through calculating its industrial agglomeration index, regional specialization index and DEA-Malmquist productivity index, has studied how industrial agglomeration and regional specialization level influence its growth of productivity. The empirical results show that the aerospace manufacturing industry agglomeration and regional specialization level are important factors to promote its productivity growth.

Keywords Aerospace manufacturing industry • Industrial agglomeration • Regional specialization • Total factor productivity

1 Introduction

As typical innovative industry, aerospace manufacturing industry is important to the transformation of the economy of a country, so it is necessary to explore an appropriate development form of industry innovation. This paper, based on the relevant data of aerospace manufacturing industry, will carry out an empirical research on the impact of industrial agglomeration and regional specialization level on the growth of productivity.

Empirical studies of foreign scholars on industrial agglomeration, mostly through analyzing spatial Gene coefficient, test if there's industry agglomeration in the related industries of the United States, and the European Union (Krugman [1];

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Audretsch and Feldman [2]; Amiti [3]). At present, empirical studies on industrial cluster have gradually increased in China, which, with the main use of CR index, V_σ-the coefficient of standard deviation and custom η value, the location of Gene coefficient, EG index and so on, have calculated agglomeration situation and the location of the manufacturing industry in mainland, analyzed the specific reasons, provided evidence for innovative economics theories, and also found that economic geography and government policy are also vital factors to lead to industry agglomeration (Xu Kangning [4]; Liang Qi [5]; Yong Luo and Cao Lili [6]; Jin Yu et al. [7]). In addition, Yin Xiguo et al. [8] has used the provincial panel data to study the phenomenon of state-owned and non-state-owned industrial agglomeration in the mainland, which has showed that economic geography, new economic geography and government intervention have significant effects on the high-tech industry agglomeration [9].

In the research of regional specialization, Bai Chongen et al. [10] has established a regional specialization index—Hoover localization coefficient, finding that the level of regional specialization is being improved. Fan Jianyong [11], by calculating the regional relative specialization index and regional specialization index, has proved that the level of regional specialization in 2001 was significantly higher than that in 1980.

However, in academia, the empirical study on joint influence of industrial agglomeration and the level of regional specialization on industry is relatively less. This article will use the relevant data of aerospace industry- an innovative manufacturing industry to study the relationship between the level of regional specialization and industrial agglomeration, and at the same time calculate Malmquist productivity index of this industry, and finally use panel data regression method to study the major effects of industrial agglomeration and regional specialization on productivity growth.

2 Industrial Agglomeration and Regional Specialization

2.1 Construction of Related Indexes

2.1.1 Industrial Agglomeration Index

At present, there are many ways to measure the industry agglomeration. In considering the space Gene coefficient (location Gene coefficient), geographic concentration index, Herfindahl-Hirschman Index (HHI), as well as the research focus and the data availability, this paper chooses Herfindahl-Hirschman Index (HHI) as the index to measure the degree of industrial agglomeration, whose construction method is as follows: to calculate working population proportion S_i ($S_i = \frac{e_i}{E_i}$) in aerospace manufacturing industry, among which, e_i represents the number of employees working in the aerospace industry in the area of i, E_i represents the number of employees of national aerospace manufacturing industry. And then in the area of i industry agglomeration HHI index of aerospace manufacturing industry is $HHI_i = S_i^2$ [12].

2.1.2 Regional Specialization Index

Location entropy is generally used to analyze industry specialization level in each area. This paper takes location entropy as an index to measure specialization degree of manufacturing aerospace industry in different areas. The calculation formula is as follows, $spec_i = \frac{e_i/e_n}{E_i/E_n}$, among which, $spec_i$ represents location entropy of aerospace manufacturing industry in the area of i; e_n represents the total number of employees in the area of i; E_n represents the total number of the employees of the nation [13].

If the regional specialization index value is greater than 1, it indicates that the industry is a regional specialized division, and a higher value means a higher specialization level of the industry.

2.2 Analysis of the Related Results

According to the characteristics of aerospace manufacturing distribution,[1] the provincial-level administrative region of the mainland is divided into six divisions in this paper, namely Northeast China, North China, East China, Central China, Southwest China and Northwest China. With the related data from the "Chinese High-Tech Statistical Yearbook" (2003–2012) (All the data in this paper are adopted from it), industry agglomeration and the degree of regional specialization level from 2002 to 2011 have been calculated. Table 1 shows the regional industrial agglomeration index of Chinese aerospace manufacturing industry in the six regions from 2002 to 2011, and Table 2 lists the regional specialization index of Chinese Aerospace manufacturing industry in the six regions from 2002 to 2011.

It can be seen from Table 1, according to the comparison of each area, the west is the main base of aerospace manufacturing industry, and the majority of enterprises in the industry are gathered here mainly because in the early development stage of the aerospace manufacturing industry China took the Western as the main base with vigorous input and support. After several large aircraft enterprises dwelled

[1]Due to the characteristics of aerospace manufacturing industry, some provinces and cities did not get involved in the distribution and development of the industry, so the relevant data of only 22 provinces with relative aerospace manufacturing aggregation have been selected in this paper. Among them, Northeast China includes Heilongjiang, Jilin and Liaoning; North China includes Beijing, Tianjin, Hebei, Shanxi and Shandong; East China includes Shanghai, Jiangsu, Anhui and Fujian; Central China includes Henan, Hubei, Hunan and Jiangxi; Southwest China includes Chongqing, Sichuan and Guizhou; Northwest China includes Shaanxi and Gansu.

Table 1 The regional industrial agglomeration index of Chinese aerospace manufacturing industry in each region in 2002–2011 years

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Northeast China	0.01558	0.01879	0.01510	0.01814	0.01646	0.01568	0.01293	0.01626	0.01104	0.01127
North China	0.00131	0.00166	0.00244	0.00170	0.00198	0.00291	0.00382	0.00329	0.00392	0.00396
East China	0.00165	0.00126	0.00131	0.00135	0.00134	0.00142	0.00107	0.00106	0.00195	0.00225
Central China	0.00700	0.00745	0.00836	0.00841	0.00814	0.00599	0.00496	0.00589	0.00596	0.00694
Southwest China	0.03168	0.02836	0.02917	0.02340	0.02355	0.02279	0.02535	0.02318	0.02323	0.02387
Northwest China	0.05802	0.05493	0.05363	0.05591	0.06492	0.06993	0.08390	0.07566	0.08021	0.08386

Data source is "Chinese High-Tech Statistical Yearbook" (2003–2012), after calculation and rearrangement

Table 2 The regional specialization index of Chinese aerospace manufacturing industry in each region in 2002–2011 years

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Northeast China	1.79753	2.10273	2.10203	2.52305	2.60120	3.11231	3.34001	4.20639	3.72324	3.93162
North China	0.39845	0.43432	0.52359	0.45280	0.49231	0.55974	0.70802	0.60763	0.68286	1.29375
East China	0.33614	0.29941	0.30864	0.30974	0.30372	0.29140	0.23573	0.23969	0.31384	0.62672
Central China	1.34461	1.42365	1.62628	1.67687	1.73157	1.79431	2.10707	2.23152	2.31837	2.51708
Southwest China	2.53895	2.48481	2.74456	2.71520	2.83450	3.35424	4.38423	4.46194	4.90070	5.83323
Northwest China	21.8327	19.9546	19.8685	22.4900	4.71308	5.83629	7.88545	8.54197	9.82415	9.86337

Data source is “Chinese High-Tech Statistical Yearbook” (2003–2012), after calculation and rearrangement here, it has become a technology intensive region with high-tech industry. As aerospace manufacturing industry belongs to high technology industry, whose input is complex and strict in its production process, it must be gathered in a limited area which can meet their requirements to achieve a steady development. Therefore, the West and Northeast have congenital advantage in the development of the aerospace industry. At the same time, according to the time sequence, the degree of agglomeration of each region shows an increasing trend annually. Consequently, industry agglomeration must be the development direction of China's aerospace industry.

From Table 2, compared with other regions, specialization level of the West has significant advantages mainly because through the development of aerospace manufacturing industry, the West has entered a more mature development stage. Compared with those regions staying in the early stage of development, its specialization level is more outstanding, and aerospace manufacturing industry has become an important industry to promote economic growth in the west. According to the time sequence, the specialization level of each region shows an increasing trend annually. Therefore, specialization level has gradually become an important factor influencing the development of aerospace industry of China.

With a comprehensive understanding of Tables 1 and 2, regional industry agglomeration and regional specialization level have certain homoplasy, namely areas with a higher degree of industrial agglomeration, their specialization level is higher. Moreover, with time passing by, both of them show an increasing tendency annually.

3 Industry Agglomeration, Regional Specialization and Productivity Growth

Whether the improvement of industry agglomeration and regional specialization can promote the development of the aerospace industry, namely the growth of productivity, is the second subject of this paper.

3.1 Calculation of DEA-Malmquist Productivity Index

Because the DEA analysis method mustn't rely on the specific form of production function, in order to avoid improper model set and the resulting deviation, in this paper (1994) [14, 15] DEA-Malmquist index method proposed by Fare is used to calculate Malmquist productivity index which is regarded as a standard to measure productivity level.

3.1.1 Models and Data Sources

From period of t to period of $t+1$, Malmquist index representing the change of productivity and its decomposition are shown in (4), (x_{t+1}, y_{t+1}) and (x_t, y_t) respectively represent the vector of input and output of the period of $t+1$ and the period of t; d_0^t and d_0^{t+1} respectively represent, with technology T^t in the period of t as the reference, the distance function of the period of t and the period of $t+1$.

$$M_0(y_{t+1}, x_{t+1}, y_t, x_t) = \frac{d_0^{t+1}(x_{t+1}, y_{t+1})}{d_0^t(x_t, y_t)} \times \left[\frac{d_0^t(x_{t+1}, y_{t+1})}{d_0^{t+1}(x_{t+1}, y_{t+1}\mathrm{C})} \times \frac{d_0^t(x_t, y_t)}{d_0^{t+1}(x_t, y_t)}\right]^{1/2}$$
$$= EC \times TP \tag{1}$$

Malmquist index at the left end of the formula can be decomposed into Technological Efficiency Change Index (*EC*) and Technological Progress Index (*TP*) under the assumption of constant scale rewards, among which, *EC* index measures the degree of every decision-making unit's running after the production possibility frontier from the period of t to the period of $t+1$, and *TP* index measures the movement of technological boundary between the period of t to the period of $t+1$.

In the calculation of Malmquist productivity index, in this paper, aerospace manufacturing industry increase in value is taken as an output indicator, net value of fixed assets as capital input, and the number of employees of each year in aerospace manufacturing industry as labor input.

3.1.2 Total Analysis of TFP Changes

With the aerospace manufacturing industry increase in value as the output variable, the actual net value of fixed assets and the number of employees as the input variables, Malmquist productivity index has been measured, and the results are as shown in Table 3.

According to the results in Table 3, in various regions, all the average of TFP over the years shows a growing trend. By comparison, the growth rate of TFP in the west and Northeast is significantly higher than in other regions, and maintains a fairly high level and increases dramatically, especially in Northwest China, up to 167 %. Meanwhile, according to Tables 1 and 2, in regions with higher industry agglomeration degree and specialization level of aerospace manufacturing industry, TFP growth rate is higher, which means that it develops faster. In general, in the past 10 years because of the unceasing enhancement of industry agglomeration degree and regional specialization level of aerospace manufacturing industry, it has been greatly promoted, and TFP has sustained a high level of growth.

Table 3 The Malmquist productivity index of Chinese aerospace manufacturing industry in various regions in 2002–2011 years

Time	North China	Northeast China	East China	Central China	Southwest China	Northwest China
2001–2002	0.89922	1.91844	1.23229	1.13585	1.69342	2.38946
2002–2003	1.28975	1.75640	1.30523	1.28984	1.53367	2.48069
2003–2004	1.33507	2.32826	1.80756	1.82180	1.87842	3.04764
2004–2005	1.14504	2.00677	1.28084	1.33257	1.85964	2.89617
2005–2006	1.06699	1.64770	1.18035	1.22616	1.77823	2.44370
2006–2007	0.96413	2.06733	1.36944	1.27437	1.93547	2.30551
2007–2008	1.15751	1.74409	1.38448	1.67574	1.95784	2.71741
2008–2009	1.12245	2.08577	1.46398	1.30971	2.00154	3.03364
2009–2010	1.20056	1.80818	1.12774	1.20293	1.73888	2.71613
2010–2011	1.13279	2.00637	1.39245	1.17638	1.97834	2.66371
Average	1.13135	1.93593	1.35444	1.34454	1.83555	2.66946

Data source is "Chinese High-Tech Statistical Yearbook" (2002–2012), after calculation and rearrangement
Data source is "Chinese High-Tech Statistical Yearbook" (2003–2012), after calculation and rearrangement

3.2 *Effects of Industrial Agglomeration and Regional Specialization on Productivity Growth*

Because the degree of industrial agglomeration and regional specialization level have the same growing direction as the productivity growth of aerospace manufacturing, this paper mainly investigates the effects of industrial agglomeration degree and regional specialization level on productivity growth.

3.2.1 Instruction of Models and Variables

According to the research needs, referring to the general model of foreign scholars, and considering the industrial agglomeration and regional specialization has certain correlation, to establish a double logarithm model can eliminate the multicollinearity among variables, so the basic model is set up as follows:

Among them, μ_{it} represents unpredictable regional effect of the aerospace manufacturing industry, ε_{it} is random perturbation, subscript i stands for the i the region, and t represents the time.

$$\ln (HTFP_{it}) = \beta_1 \ln HHI_{it} + \beta_2 \ln spec_{it} + \mu_{it} + \varepsilon_{it} \quad (2)$$

Referring to existing literature and economic significance, the average size of enterprises, degree of competition in the industry and R & D investment within the region are the main factors affecting productivity growth. Therefore, the above three variables are introduced as control variables. Among them, because R & D input has a time-delayed effect on TFP change, the lag item of R & D input is taken to be R & D input variable. The extended model is obtained as follows:

$$\ln\left(HTFP_{it}\right) = \beta_1 \ln HHI_{it} + \beta_2 \ln spec_{it} + \beta_3 \ln RD_{it-j} + \beta_4 \ln scale_{it} + \beta_5 \ln comp_{it} + \mu_{it} + \varepsilon_{it} \tag{3}$$

And then considering cross effect of industrial agglomeration and regional specialization level, the final model will be obtained as follows:

$$\ln\left(HTFP_{it}\right) = \beta_1 \ln HHI_{it} + \beta_2 \ln spec_{it} + \beta_3 \ln RD_{it-j} + \beta_4 \ln scale_{it} + \beta_5 \ln comp_{it} + \beta_6 \ln\left(HHI_{it} \times spec_{it}\right) + \mu_{it} + \varepsilon_{it} \tag{4}$$

The variables in the three models have the following meaning:

(1) $HTFP_{it}$: the representative of the total factor productivity of aerospace manufacturing industry in i area during the period of t, as the dependent variable, represented by Malmquist productivity index of aviation manufacturing industry in various regions calculated above in this paper.
(2) HHI_{it}: the representative of the industrial agglomeration degree of the aerospace industry in i area during the period of t, represented by the HHI index of the aerospace manufacturing industry in various regions calculated above in this paper.
(3) $spec_{it}$: the representative of the specialization level of aerospace manufacturing industry in i area during the period of t, represented by the regional specialization index of the aerospace manufacturing industry in various regions calculated above in this paper.
(4) RD_{it-j}: the representative of input of R&D of aerospace manufacturing industry in i area during the lag period of $t-j$, represented by R&D activities expenditures of the aerospace manufacturing industry during the lag period of $t-j$ in this paper.
(5) $scale_{it}$: the representative of the average scale of enterprise concerning industrial agglomeration degree in i area during the period of t, represented by the ratio between industrial added value of aerospace manufacturing enterprise and the number of enterprise of aerospace manufacturing industry in various regions in this paper.
(6) $comp_{it}$: the representative of the degree of competition of aerospace manufacturing industry in i area during the period of t, represented by the number of enterprise of aerospace manufacturing industry owned by every million people in i area during the period of t in this paper.

Table 4 Regression results of models

Explanatory variables	Basic Model 1(Re)	Extended Model 2(Fe)	Final Model 3(Fe)
C	0.81185***	−0.24498	0.10075
	(3.05683)	(−0.79513)	(0.49985)
HHI	0.07971*	0.06272**	0.07080***
	(1.65257)	(2.06480)	(2.99051)
spec	0.09193*	0.07695**	0.33880***
	(1.94066)	(2.62206)	(8.50898)
RD_{-1}		0.00557***	0.06025***
		(3.55622)	(3.12489)
scale		−0.11013***	−0.07175**
		(−2.94428)	(−2.28140)
comp		−0.10177**	−0.20031***
		(−2.50472)	(−5.26521)
$HHI \times spec$			0.07177***
			(10.60163)
Hausman	2.10949	41.61296	11.07024
R^2	0.68381	0.94660	0.96218
Adj. R^2	0.66293	0.94092	0.95724
F	6.18282	166.6265	195.0225
D. W.	1.94791	1.61224	1.86761

Data source is "Chinese High-Tech Statistical Yearbook" (2003–2012), "Chinese Statistical Yearbook" (2003–2012), and "Chinese Population and Employment Statistics Yearbook" (2003–2012), after calculation and rearrangement

Note: The data in parentheses is t value, ***, **, * respectively denote significant at 1 %, 5 % and 10 % level

RE represents a random effect model, *FE* represents a fixed effect model

3.2.2 Analysis of Regression Results

In the three models, if μ_{it} is the fixed parameter to be estimated, and the residual random disturbance follows $\varepsilon_{it} \sim N(0,\sigma^2)$, then the expression is a fixed effect model (FE), if the residual μ_{it} is random, then the expression is the random effect model (RE), which can be decided by the Hausman test. Statistical values of Hausman test on models set by type (2), (3) and (4) are respectively 2.10949, 41.61296 and 11.07024, so, the random effect model is set up for the type (2) namely Model 1, the fixed effect model is established for the type (3) namely Model 2, the fixed effect model is established for the type (4) namely Model 3. In order to eliminate the heteroscedasticity in the model and contemporaneous correlation, for the fixed effect model, Cross-section SUR is adopted to fix effect. For R&D, after repeatable pilot calculation, one period lagged variable is adopted. Table 4 lists the regression results of basic model, extended model and final model by using SUR method. Among them, Model 1, 2 and 3 are respectively estimated results based on basic model, extended model and final model. Overall, *D. W.* values of three models are relatively close to 2, and there is no self-correlation for models. In addition, the three models have passed the significant test as a whole, and their goodness-of-fit is better. From

Model 1 to Model 3, goodness-of-fit gradually increases, which means that with the gradual introduction of variables, regression effect of equation becomes ideal gradually.

4 Results

We can do further analysis of the empirical results:

A. *The Degree of Industrial Agglomeration has a Positive Effect on Aerospace Manufacturing Productivity Growth.*

The regression coefficients of industrial agglomeration degree are positive, and in Model 1, Model 2 and Model 3 have respectively passed significance test by 10 %, 5 % and 1 % level. It's obvious that the industry agglomeration degree in a region can greatly promote productivity growth.

B. *The Level of Regional Specialization has a Positive Effect on Aerospace Manufacturing Productivity Growth.*

Estimated results of models show that, the promotion of the specialized level in a region plays a significant role in improving productivity growth. Its significance and influence coefficient are stronger than those of the degree of industrial agglomeration, which indicates that, the degree of industrial agglomeration of aerospace manufacturing industry promotes economic growth less significantly than the regional specialization level. The possible reason is that a large number of enterprises have not gradually divided and specialized in the agglomeration process to form cluster but only agglomerated in geography.

C. *The Joint Effect of Industrial Agglomeration Degree and Regional Specialization Level has a Positive Effect on Aerospace Manufacturing Productivity Growth.*

Through the study of Model 3, the combined effect of industrial agglomeration degree and regional specialization level has played a very significant role in promoting productivity growth.

D. *R&D Investment has a Positive Effect on the Productivity Growth of Aerospace Manufacturing Industry, while Firm Size and Regional Competition has a Negative Effect on the Productivity Growth.*

From the regression results of Model 2 and Model 3, it can be seen that the R&D investment promotes economic growth less significantly than the degree of industrial agglomeration. The regression coefficient of enterprise scale and regional competition degree are negative, indicating that controlling the scale of enterprise and the degree of competition is the necessary means to promote aerospace manufacturing productivity. At the same time, by comparing the regression coefficients, the degree of competition within a region plays a more obviously prohibitive role on converting input to output than enterprise scale.

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Applying Interval Linguistic Variables on Project Evaluation of New Product Development

Chen-tung Chen, P.C. Fu, and W.Z. Hung

Abstract In recent years, the global financial storm causes the enterprises to face challenges more severely. To survive in the markets, the enterprises should provide the new products or services continuously to increase their competitiveness. However, the evaluation process of a new product development (NPD) project may face the uncertainties of technology and market in the future. It means that a NPD project will face the higher investment risk. To reduce development costs and risks, an effective evaluation model of the NPD project has become more important issue for enterprises. In this paper, a systematic evaluation model of new product development project is proposed by combining interval 2-tuple linguistic variables with multiple criteria decision making (MCDM). And then, a numerical example is implemented to illustrate the computation process of proposed model. Finally, the conclusion is provided at the end of this paper.

Keywords Interval 2-tuple linguistic variables • Multiple criteria decision making • New product development projects

1 Introduction

In recent years, the global financial turmoil has intensified negative impacts on the world economy. For the sake of assuring survival and increasing competitive advantage, enterprises should continuously introduce new products or services to

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increase their revenues and enhance their competitiveness [1]. A successful new product development (NPD) project will increase profits and competitive advantages for a company, but a failed project could pose a significant impact on the business operation. Therefore, a successful NPD project is a key factor for enterprises to increase their competitiveness. Barczak et al., pointed out that more than one-third of sales profits came from the development of new products within 5 years [2]. Furthermore, some studies showed that new products have made contributions to sales revenues and profits on a consistent upward trend from 20 % in the 1970s to 50 % in the 1990s [3–5]. Therefore, businesses can only rely on continuous development of new products or services to ensure their survival and thereby enhance their competitive advantages in the market.

A successful NPD project has become the most important factor for a company to create profits and competitive advantages; therefore, a systematic evaluation model of the possibility of success in NPD project has become an essential issue. Many influenced factors should be considered in the evaluation process of NPD projects. Therefore, it can be formulated as a multiple criteria decision making (MCDM) problem. Most of the traditional MCDM methods assume that both evaluation results and weights of criteria are crisp values for conducting decision-making rating and ranking. In real environment, decision-makers could probably need to encounter some evaluation criteria with fuzzy and qualitative characteristics, and hence the decision problems became more complex and difficult. Therefore, Bellman and Zadeh applied the fuzzy set theory in the decision-making environment firstly [6]. Since then, the fuzzy set theory is considered to be an important methodology to establish evaluation models for decision problems. The fuzzy set theory was widely applied in engineering, business, natural science and medical researches [7–9].

This paper will incorporate the fuzzy theory with MCDM methods based on 2-tuple interval linguistic variables to construct an evaluation model for measuring the degree of success of a new product development project.

2 Literature Review

2.1 Evaluation Methods of NPD Projects

During the implementation of a new product development project, the enterprises conduct periodic evaluations to ensure that the project can be successful and performed efficiently.

Wang proposed a 2-tuple fuzzy linguistic computing approach to measure the performance of a new product development project for an actual company [10]. Oliveira and Rozenfeld proposed a new method to support the development of front-end activities based on technology road mapping (TRM) and project portfolio management (PPM) methodologies [11]. Liu propounded a method of combining

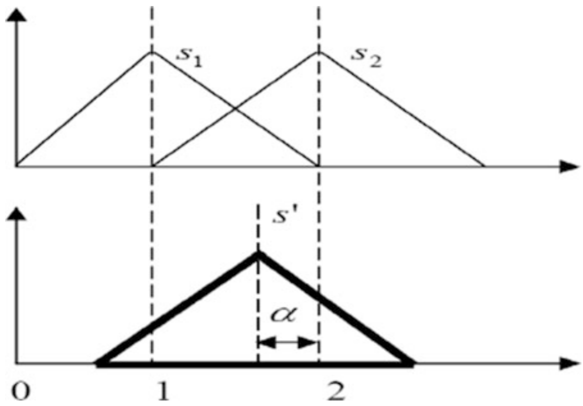

Fig. 1 The definition of 2-tuple linguistic variable

fuzzy and quality function deployment (QFD) for considering the necessary and quickness of product function changes which cause the needs to short process of NPD. Therefore, enterprises must develop a new product which can satisfy the requirement of consumers in a short time [12]. Senthil proposed the hybrid methodology based on analytical hierarchy process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) under fuzzy environment for selection and evaluation of reverse logistics operating channels [13]. In this paper, we combine 2-tuple linguistic variables and SAW method to help decision markers evaluate the possibility of success of a new product development project.

2.2 *The 2-Tuple Fuzzy Linguistic Variables*

Herrera and Martinez proposed the 2-tuple fuzzy linguistic representation model and used linguistic variables by two parameters with label $L=(s,\alpha)$ [14]. The parameter s is a value of the fuzzy linguistic variable. For example, let $S=\{s_0$: very unimportant, s_1: unimportant, s_2: fair, s_3: important, s_4: very important$\}$, then $s \in S$. The parameter α is the distance between s and the desired linguistic variable. If linguistic variable's value s' is between s_1 and s_2, then $L' = (s_2, \alpha)$ can be represented by using a 2-tuple linguistic variable as shown in Fig. 1.

In fact, decision makers based on their expertise in different situations would select suitable 2-tuple linguistic variables as evaluation basis. Different types of linguistic variables can also be set by different membership functions as shown in Table 1 [15].

Chen and Chen combined the concepts of 2-tuple linguistic variables and ordinal proportional 2-tuple sets that permit judgment by using not only single linguistic variable but also two adjacent linguistic variables for representing expert's subject opinions adequately [15]. Assume that l_i $(i=0, 1, \ldots, n-1)$ is a 2-tuple linguistic

Table 1 Different types of linguistic variables

Figure	Linguistic variable	
5-scale linguistic variables (Fig. 2)	Evaluation values	Very low (s_0^5), low (s_1^5), medium (s_2^5), high (s_3^5), very high (s_4^5)
	Weights	Very unimportant (s_0^5), unimportant (s_1^5), medium (s_2^5), important (s_3^5), very important (s_4^5)
7-scale linguistic variables (Fig. 3)	Evaluation values	Pretty low (s_0^7), very low (s_1^7), low (s_2^7), medium (s_3^7), high (s_4^7), very high (s_5^7), pretty high (s_6^7)
	Weights	Pretty unimportant (s_0^7), very unimportant (s_1^7), unimportant (s_2^7), medium (s_3^7), important (s_4^7), very important (s_5^7), pretty important (s_6^7)
9-scale linguistic variables (Fig. 4)	Evaluation values	Extremely low (s_0^9), pretty low (s_1^9), very low (s_2^9), low (s_3^9), medium (s_4^9), high (s_5^9), very high (s_6^9), pretty high (s_7^9), extremely high (s_8^9)
	Weights	Extremely unimportant (s_0^9), pretty unimportant (s_1^9), very unimportant (s_2^9), unimportant (s_3^9), medium (s_4^9), important (s_5^9), very important (s_6^9), pretty important (s_7^9), extremely important (s_8^9)

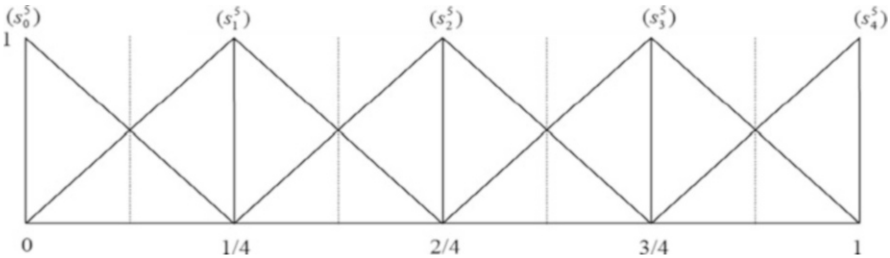

Fig. 2 Membership functions of five scale linguistic variables

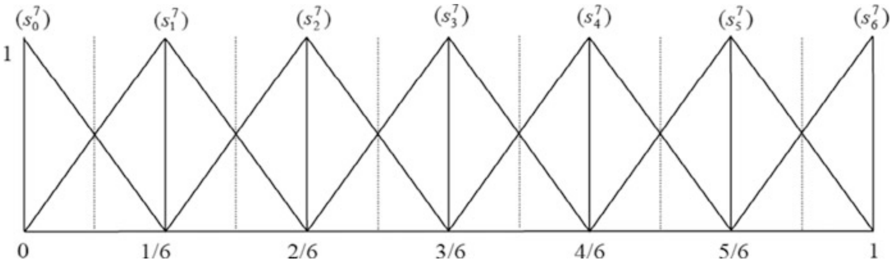

Fig. 3 Membership functions of seven scale linguistic variables

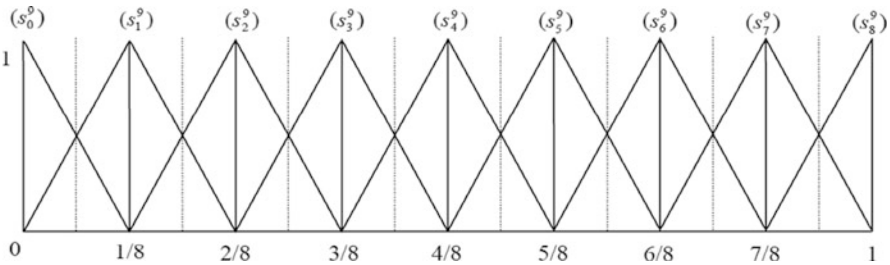

Fig. 4 Membership functions of nine scale linguistic variables

variable and represent it by $l_i = (s_i, \alpha_i)$. Let $\overline{L_i} = (pl_i, (1-p)\ l_{i+1})$ and the equations shown below can be used to transform $\overline{L_i}$ into crisp value β ($\beta \in [0,1]$) and the reverse.

$$\overline{\Delta}^{-1}\left(\overline{L_i}\right) = \overline{\Delta}^{-1}\left(pl_i, (1-p)\ l_{i+1}\right)$$
$$= p \cdot \Delta^{-1}(s_i, \alpha_i) + (1-p) \cdot \Delta^{-1}(s_{i+1}, \alpha_{i+1}) = \beta \tag{1}$$

$$\overline{\Delta}(\beta) = (pl_i, (1-p)\ l_{i+1}) \tag{2}$$

where $\Delta^{-1}(s_i,\alpha_i) \le \beta \le \Delta^{-1}(s_{i+1},\alpha_{i+1})$, $p = g \cdot (\Delta^{-1}(s_{i+1},\alpha_{i+1}) - \beta)$ and the reverse function Δ^{-1} was defined in [16].

Transform an interval linguistic variable with $n(t)$-scale $(pl_i^{n(t)}, (1-p)\ l_{i+1}^{n(t)})$ into $n(t+1)$-scale $(ql_k^{n(t+1)}, (1-q)\ l_{k+1}^{n(t+1)})$ as follows.

$$TF_{t+1}^{t}\left(pl_i^{n(t)}, (1-p)\ l_{i+1}^{n(t)}\right) = \overline{\Delta}_{t+1}\left(\overline{\Delta}_t^{-1}\left(pl_i^{n(t)}, (1-p)\ l_{i+1}^{n(t)}\right)\right)$$
$$= \left(ql_k^{n(t+1)}, (1-q)\ l_{k+1}^{n(t+1)}\right) = \left(qs_k^{n(t+1)}, (1-q)\ s_{k+1}^{n(t+1)}\right) \tag{3}$$

where, $q = g_{t+1} \cdot (\Delta_t^{-1}(s_{i+1}^{n(t+1)},0) - \beta)$, $g_{t+1} = n(t+1) - 1$, and $\Delta_{t+1}^{-1}(s_k^{n(t+1)},0) \le \beta \le \Delta_{t+1}^{-1}(s_{k+1}^{n(t+1)},0)$.

3 The Proposed Method

3.1 To Establish Evaluate Hierarchy Framework

To effectively evaluate the possibility of success in an NPD project, decision makers must collect critical factors and screen criteria index to build up a hierarchical structure of the probability evaluation. Suppose that there are n evaluation dimensions and each dimension contains t_i ($i = 1, 2, \ldots, n$) evaluation indices. The hierarchical structure can be specified as Fig. 5.

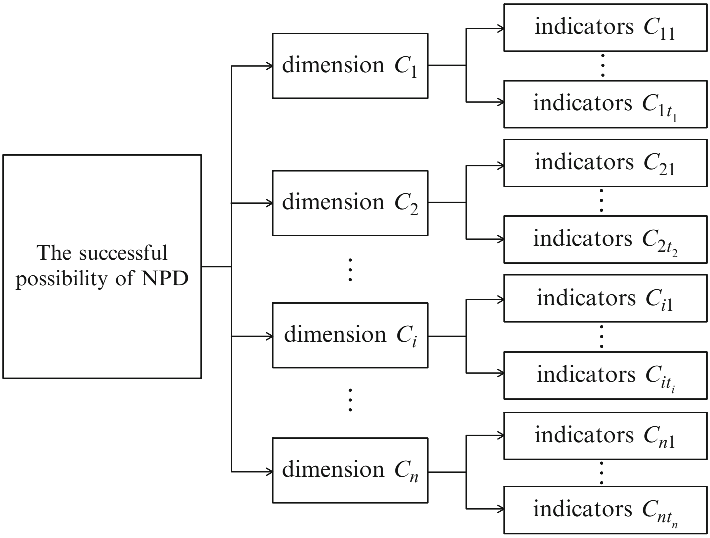

Fig. 5 Hierarchical evaluation framework

3.2 Evaluation Process

According to the evaluation framework, the evaluation process of the proposed model is illustrated as follows.

Step 1. Each expert can select suitable linguistic variables based on their knowledge or experiences (shown as Table 3).

Step 2. Experts provide the interval 2-tuple linguistic weights with respect to each dimension and indicator.

Step 3. Each expert offers the interval 2-tuple linguistic evaluation values with respect to indicator in each dimension.

Step 4. Transform interval linguistic variables into the same type to aggregate the linguistic evaluation values and weights.

Step 5. Compute the weight of each indicator by aggregating the linguistic weights of K experts. The calculation can be shown as

$$\tilde{w}_i = \frac{1}{K}\left(\tilde{w}_i^1 + \tilde{w}_i^2 + \cdots + \tilde{w}_i^K\right), \quad k = 1, 2, \ldots, K \tag{4}$$

where $\tilde{w}_i = \left[w_i s_m^z, (1 - w_i)\ s_{m+1}^z\right]$ is the interval linguistic weight of the i-th dimension, and $\tilde{w}_i^k = \left[w_i^k s_m^z, \left(1 - w_i^k\right)\ s_{m+1}^z\right]$ is the k-th expert's interval weight of the i-th dimension.

Step 6. Aggregate the linguistic weights of k experts with respect to each indicator under each dimension. The calculation can be shown as

$$\tilde{w}_{ij} = \frac{1}{K}\left(\tilde{w}_{ij}^{1} + \tilde{w}_{ij}^{2} + \cdots + \tilde{w}_{ij}^{K}\right), \quad j = 1, 2, \ldots, t_i \tag{5}$$

where $\tilde{w}_{ij}^{k} = \left[w_{ij}^{k} s_m^z, \left(1 - w_{ij}^{k}\right) s_{m+1}^{z}\right]$ is the interval linguistic weight of the k-th expert with respect to the j-th indicator in dimension C_i.

Step 7. Aggregate the linguistic evaluation values of K experts with respect to each indicator under each dimension. The calculation can be shown as

$$\tilde{X}_{ij} = \frac{1}{K}\left(\tilde{X}_{ij}^{1} + \tilde{X}_{ij}^{2} + \cdots + \tilde{X}_{ij}^{K}\right), \quad j = 1, 2, \ldots, t_i \tag{6}$$

where $\tilde{X}_{ij}^{k} = \left[X_{ij}^{k} s_m^z, \left(1 - X_{ij}^{k}\right) s_{m+1}^{z}\right]$ is the k-th expert's interval linguistic evaluation value of the j-th indicator in dimension C_i.

Step 8. Calculate the aggregated interval evaluation value of each dimension as

$$\tilde{X}_i = \overline{\Delta}\left[\frac{\sum_{j=1}^{t_i} \overline{\Delta}^{-1}\left(\tilde{X}_{ij}\right) \cdot \overline{\Delta}^{-1}\left(\tilde{w}_{ij}\right)}{\sum_{j=1}^{t_i} \overline{\Delta}^{-1}\left(\tilde{w}_{ij}\right)}\right], \quad i = 1, 2, \ldots, n \tag{7}$$

where $\tilde{X}_i = \left[X_i s_m^z, (1 - X_i)\ s_m^z\right]$ is the weighted interval evaluation value in the i-th dimension.

Step 9. Compute the degree of success of the NPD project as

$$\tilde{p} = \Delta\left[\frac{\sum_{i=1}^{n}\left(\overline{\Delta}^{-1}\left(\tilde{X}_i\right) \cdot \overline{\Delta}^{-1}\left(\tilde{w}_i\right)\right)}{\sum_{i=1}^{n} \overline{\Delta}^{-1}\left(\tilde{w}_i\right)}\right] \tag{8}$$

where $\tilde{p}$ is the successful possibility of the NPD project and it can be represented in interval linguistic variables.

4 An Example

Suppose that a company want to evaluate the successful possibility of an NPD project. Three experts are formed a decision group. The evaluation dimensions include technology ability (C_1), marketing ability (C_2), and management ability (C_3). The evaluation indicators of each dimension are research technology ability of product (C_{11}), new product quality (C_{12}), market acceptance (C_{21}), possibility of

Table 2 The importance of each dimension

Dimensions	Weights		
	D_1	D_2	D_3
C_1	$(0.3s_3^5, 0.7s_4^5)$	$(0s_4^7, 1s_5^7)$	$(0s_6^9, 1s_7^9)$
C_2	$(0s_2^5, 1s_3^5)$	$(0.5s_5^7, 0.5s_6^7)$	$(0.3s_6^9, 0.7s_7^9)$
C_3	$(0s_2^5, 1s_3^5)$	$(0.5s_3^7, 0.5s_4^7)$	$(0.4s_7^9, 0.6s_8^9)$

Table 3 The importance of indicators in each dimension

Dimensions	Indicators	Weights		
		D_1	D_2	D_3
C_1	C_{11}	$(0.3s_3^5, 0.7s_4^5)$	$(0s_2^7, 1s_3^7)$	$(0s_5^9, 1s_6^9)$
	C_{12}	$(0.5s_3^5, 0.5s_4^5)$	$(0.3s_3^7, 0.7s_4^7)$	$(0.5s_6^9, 0.5s_7^9)$
C_2	C_{21}	$(0s_2^5, 1s_3^5)$	$(0s_3^7, 1s_4^7)$	$(0s_5^9, 1s_6^9)$
	C_{22}	$(0s_2^5, 1s_3^5)$	$(0.5s_5^7, 0.5s_6^7)$	$(0.8s_7^9, 0.2s_8^9)$
	C_{23}	$(0.8s_3^5, 0.2s_4^5)$	$(0s_5^7, 1s_6^7)$	$(0.5s_6^9, 0.5s_7^9)$
C_3	C_{31}	$(0.2s_1^5, 0.8s_2^5)$	$(0.2s_4^7, 0.8s_5^7)$	$(0.3s_7^9, 0.7s_8^9)$
	C_{32}	$(0.5s_2^5, 0.5s_3^5)$	$(0s_3^7, 1s_4^7)$	$(0s_7^9, 1s_8^9)$

Table 4 The evaluation values of all indicators

Dimensions	Indicators	Values		
		D_1	D_2	D_3
C_1	C_{11}	$(0s_3^5, 1s_4^5)$	$(0s_3^7, 1s_4^7)$	$(0.3s_6^9, 0.7s_7^9)$
	C_{12}	$(0.5s_3^5, 0.5s_4^5)$	$(0.5s_3^7, 0.5s_4^7)$	$(0s_5^9, 1s_6^9)$
C_2	C_{21}	$(0.3s_2^5, 0.7s_3^5)$	$(0.3s_5^7, 0.7s_6^7)$	$(0.5s_5^9, 0.5s_6^9)$
	C_{22}	$(0.7s_3^5, 0.3s_4^5)$	$(0.5s_5^7, 0.5s_6^7)$	$(0s_5^9, 1s_6^9)$
	C_{23}	$(0s_2^5, 1s_3^5)$	$(0s_2^7, 1s_3^7)$	$(0.5s_5^9, 0.5s_6^9)$
C_3	C_{31}	$(0s_1^5, 1s_2^5)$	$(0.5s_5^7, 0.5s_6^7)$	$(0.3s_7^9, 0.7s_8^9)$
	C_{32}	$(0s_2^5, 1s_3^5)$	$(0s_4^7, 1s_5^7)$	$(0s_7^9, 1s_8^9)$

new product profitability (C_{22}), market competition strength (C_{23}), human resource of new product development (C_{31}), and support degree of top manager (C_{32}).

The computational procedure of proposed method is shown as follows.

Step 1. The experts select suitable scales of linguistic variables to express their opinions (shown in Table 1).
Step 2. The importance of dimensions and indicators given by the three experts are shown in Tables 2 and 3.
Step 3. The evaluation values of all indicators are shown in Table 4.
Step 4. Transforming linguistic variables' values given by expert D_1 and D_3 into variables with 7-scale.
Step 5. The 2-tuple interval linguistic weights of dimensions are shown in Table 5.
Step 6. The 2-tuple interval linguistic weights of all indicators are shown in Table 6.

Table 5 Average 2-tuple interval linguistic weights of all dimensions

Dimensions	Average weights	Linguistic variables
C_1	$(0.733\ s_5^7, 0.267\ s_6^7)$	(0.733 very important, 0.267 pretty important)
C_2	$(0.992\ s_5^7, 0.008\ s_6^7)$	(0.992 very important, 0.008 pretty important)
C_3	$(0.433\ s_4^7, 0.567\ s_5^7)$	(0.433 important, 0.567 very important)

Table 6 Average 2-tuple interval linguistic weights of all indicators

Dimensions	Indicators	Average weights
C_1	C_{11}	$(0.65s_4^7, 0.35s_5^7)$
	C_{12}	$(0.392s_4^7, 0.608s_5^7)$
C_2	C_{21}	$(0.667s_4^7, 0.333s_5^7)$
	C_{22}	$(0.867s_5^7, 0.133s_6^7)$
	C_{23}	$(0.775s_5^7, 0.225s_6^7)$
C_3	C_{31}	$(0.575s_4^7, 0.425s_5^7)$
	C_{32}	$(0.417s_4^7, 0.583s_5^7)$

Table 7 Average 2-tuple interval linguistic evaluation values of all indicators

Dimensions	Indicators	Average evaluation values
C_1	C_{11}	$(0.992s_5^7, 0.008s_6^7)$
	C_{12}	$(0.583s_4^7, 0.417s_5^7)$
C_2	C_{21}	$(0.375s_4^7, 0.625s_5^7)$
	C_{22}	$(0.017s_4^7, 0.983s_5^7)$
	C_{23}	$(0.125s_3^7, 0.875s_4^7)$
C_3	C_{31}	$(0.242s_4^7, 0.758s_5^7)$
	C_{32}	$(0.833s_5^7, 0.167s_6^7)$

Table 8 The aggregated values of three dimensions

Dimensions	Aggregated values	Linguistic variable
C_1	$(0.296s_4^7, 0.704s_5^7)$	(0.296 important, 0.704 very important)
C_2	$(0.511s_4^7, 0.489s_5^7)$	(0.511 important, 0.489 very important)
C_3	$(0.034s_4^7, 0.966s_5^7)$	(0.034 important, 0.966 very important)

Step 7. Compute the aggregated evaluation value of each indicator. The 2-tuple interval linguistic evaluation values of all indicators are shown in Table 7.

Step 8. Calculate the aggregated value of each dimension. For example, the aggregated evaluation value of "technology ability" can be computed as

$$\overline{\Delta}\left[\frac{\Delta^{-1}\left(0.992s_5^7, 0.008s_6^7\right)\times\overline{\Delta}^{-1}\left(0.65s_4^7, 0.35s_5^7\right)+\overline{\Delta}^{-1}\left(0.583s_4^7, 0.417s_5^7\right)\times\overline{\Delta}^{-1}\left(0.392s_4^7, 0.608s_5^7\right)}{\overline{\Delta}^{-1}\left(0.65s_4^7, 0.35s_5^7\right)+\overline{\Delta}^{-1}\left(0.392s_4^7, 0.608s_5^7\right)}\right]$$
$$= \left(0.296s_4^7, 0.704s_5^7\right)$$

By using the same steps, the aggregated values of three dimensions are calculated and shown in Table 8.

Step 9. Compute the degree of successful possibility of an NPD project as

$$\overline{\Delta}\left[\frac{\overline{\Delta}^{-1}\left(0.871s_4^7, 0.129s_5^7\right) + \overline{\Delta}^{-1}\left(0.253s_3^7, 0.747s_4^7\right) + \overline{\Delta}^{-1}\left(0.22s_3^7, 0.78s_4^7\right)}{\overline{\Delta}^{-1}\left(0.733s_5^7, 0.267s_6^7\right) + \overline{\Delta}^{-1}\left(0.992s_5^7, 0.008s_6^7\right) + \overline{\Delta}^{-1}\left(0.433s_4^7, 0.567s_5^7\right)}\right]$$

$$= \left(0.288s_4^7, 0.712s_5^7\right)$$

It means that the successful degree of the NPD project is between “high” and “very high”.

5 Conclusions

It is an important issue for every business to evaluate the degree of possibility success of an NPD project effectively. In this paper, the 2-tuple fuzzy interval linguistic variables are used to express the subjective opinions of decision makers. The proposed model combines fuzzy set theory with MCDM method to construct a systematic evaluation model of success possibility for new product development projects. According to the computation results of the example, we find that the proposed method can measure the success possibility of new product development project effectively. The measurement result of the proposed method is more reasonable for decision maker to understand the risk of the NPD project.

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Part II
Decision Analysis/Decision Support System

The Equipment Maintenance Mode Allocated D-Logical Decision Model and Its Economic Tradeoff Strategies

Hong-gen Chen

Abstract This paper outlines some of the basic methods and strategies on maintenance mode allocation decision and presents a D-logic decision model based on logical thought to guide the maintenance allocation decisions. Aiming at the problem of maintenance mode economic difference involving in the model, the economic tradeoff strategies is built, which takes average cost per unit time for object, to guide the selection of economy of maintenance modes. By comparing with the traditional logic decision models, the results suggest that the D-logic decision model is more advantages in model complexity, economic guarantee and managerial flexibility.

Keywords D-logic decision model • Equipment maintenance mode • Economic tradeoff

1 Introduction

According to the different maintenance work time and control type, present maintenance modes can be divided into breakdown maintenance, timing maintenance, condition maintenance and improved maintenance [1]. For the equipment systems, it is impossible to find a maintenance mode which is suitable for any system, any machine. So, for different maintenance object, different maintenance mode must be used according to concrete features and conditions in order to realize the on-condition decision of maintenance mode.

On the study of maintenance mode allocation decision, the current researches focus on logic analysis decision-making method and cost analysis decision-making

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method. Bevilacqua M and Braglia M [2] built a maintenance mode selection model based on AHP, and applied to practical performance; Bertolini M and Bevilacqua M [3] made an optimization to this method combine with multiple objective programming methods, and built a comprehensive model of multiple objective programming-AHP to maintenance mode decision. Gong-qian LIANG and Xiang-yu CHEN [4] built a balance mode of breakdown maintenance and preventive maintenance based on failure shutdown loss cost and part replacement cost, and analyzed the select ion o f optimal maintenance strategy of three different reliability distribution functions. After this, Yu-jiong GU and Kun-liang CHEN [5] suggested the fuzzy comprehensive evaluation method based on entropy weight and AHP aiming at the difficulty in selecting the maintenance mode for power plant equipment, which solves the casualness and subjectivity problem about weight decision in traditional fuzzy comprehensive evaluation method; WANG Yi and Hui-fang WANG [6] proposed a maintenance type selection model based on effectiveness and cost analysis using CBM information, and this model is suitable for power equipment maintenance management and can help maintenance staff make economic and effective maintenance arrangement; Bashiri M and Badri H [7] built a maintenance mode selection and optimization decision model based on fuzzy linear assignment method; Li-li LI and Xiao-jun ZHOU [8] proposed a combined fuzzy analytic hierarchy process-goal programming decision model based on the hierarchy structure of the factors and the failure mode, effects and criticality analysis. V Zille and et al. [9] present a modelling approach to assess the performance of multicomponent systems maintained by complex maintenance strategies, which can be used as a decision-making tool to choose from a selection of various maintenance options. The main originality of the mode is that the complexity of both maintenance programmes and system structures is taken into account. Shahin and et al. [10] proposes an approach to determine suitable maintenance strategy with the aid of analytic network process (ANP). Mohammad Majid Fouladgar and et al. [11] proposes a complex multi-criteria decision making to evaluate the feasible maintenance strategy under fuzzy environment. To help the maintenance managers/decision makers to select a suitable maintenance strategy for the components/parts associated with the system, an approach to select the most effective and efficient maintenance strategy is presented by Sharma et al. based on fuzzy linguistic modeling [12].

The follows are the main contents of this paper. According to the deficiency of tradition logic decision graph, from the comprehensive point of equipment fault consequences analysis and fault mode feature, this paper put forwards an improved logic decision structure model of maintenance mode allocation.

2 D-Logic Decision Model for Equipment Maintenance

Logic decision-making method can also be called logic judge methods to comprehensive target, and this method references the thought of TPM and ABC classification technique and takes RCM as theoretical basis [13]. According to the demand of decision objects, put forward a series of logic problems of equipment performance index and on the basis of answers, maintenance mode can be suggested and implemented, and the representative methods are RCM1(MSG3) and RCM2 [14]. But from the point of maintenance practice, RCM1 and RCM2 have some improvement [15]. Firstly, in the logic decision analysis, as the two methods should classify and decide according to failure consequence, there exist plenty of repeat in logic decision graph; secondly, the two methods imply the influence of fault feature in the principles of applicability and effectiveness, so, it is fuzzy when analyzing; thirdly, in aspect of economy, the two methods consider the cost comparison of preventive maintenance mode and its breakdown maintenance mode, but they cannot consider the cost comparison of different preventive maintenance modes. According to the deficiency of RCM1 and RCM2 logic decision graph, from the comprehensive point of equipment fault consequences analysis and fault mode feature, this paper put forwards an improved logic decision structure model of maintenance mode allocation (D-logic decision model).

2.1 Decision Framework of D-Logic Decision Model for Equipment Maintenance

The framework of D-logic decision model established in the paper is shown as Fig. 1. The model can be divided into three parts as following.

The first part: the decision between breakdown maintenance and preventive maintenance. For the maintenance objects which have been in fault state, and the maintenance objects whose fault have no safety and environment influence and also it is economic and effective to take breakdown maintenance mode, the breakdown maintenance mode should be taken; or else the preventive maintenance mode should be taken.

The second part: the decision between timing maintenance and condition maintenance mode. For the maintenance objects which need preventive maintenance, if timing maintenance and condition maintenance both are technical feasibility and effective, then the principle of economic is used to make a choice. If only condition maintenance is technical feasibility and effective, then it is used. If only timing maintenance is technical feasibility and effective, then it is used.

The third part: the decision of corrective maintenance. According to the maintenance objects which need preventive maintenance, if they cannot pass timing maintenance mode and condition maintenance mode to prevent the consequences of fault or multiple faults, but the corrective maintenance technology is feasible and effective, then corrective maintenance mode should be taken, otherwise the data must be re-collected or the abandonment work must be adopted.

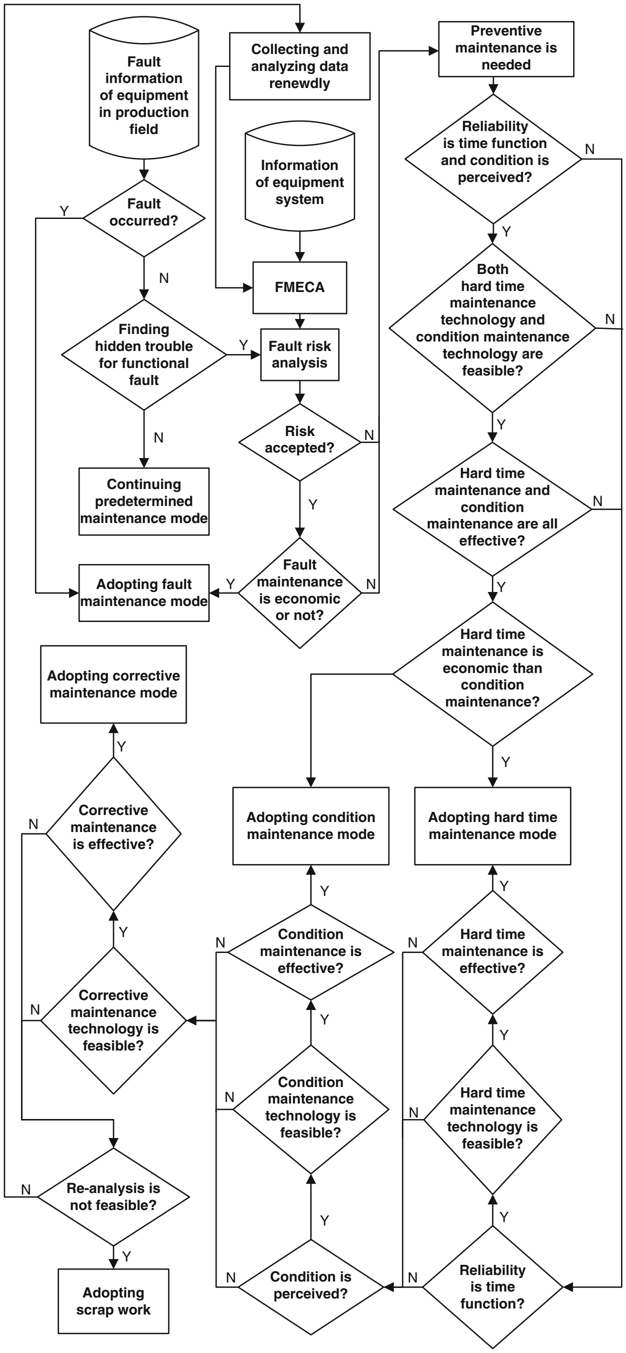

Fig. 1 The D-logic decision model of maintenance mode allocated

2.2 Economic Tradeoff Strategy in D-Logic Decision Model for Equipment Maintenance

From Fig. 1, there are two economic tradeoff points in D-logic decision model, and the first is economic tradeoff between breakdown maintenance and preventive maintenance; the second is economic tradeoff between timing maintenance and condition maintenance. Therefore, when using the D-logic decision model, the economic tradeoff model must be contributed to compare the breakdown maintenance, condition maintenance and timing maintenance.

Assumption: (1) C_T is the average maintenance cost per time unit of preventive maintenance mode, that is in time T, the maintenance activities have conducted; (2) C_∞ is the average maintenance cost per time unit of breakdown maintenance mode, that is in fault time $t \to \infty$, the maintenance activities have conducted; (3) the management cost and other extra input cost are involved in preventive maintenance, and are not in breakdown maintenance; (4) the loss of shutdown will be exist because of the breakdown maintenance caused by emergency. As to a maintenance object, there are:

$$C_\infty = \frac{C_0 + C_F}{M + T_r} \tag{1}$$

$$C_T = \frac{C_0 + C_E + [1 - R(T)]\,C_F}{M_T + T_r} \tag{2}$$

In the equation, $R(T)$ is the reliability function of the equipment working to time T; C_0 is the cost of replacement parts, which involve parts cost, time cost and additional materials cost; C_E is inspection, monitoring and other extra costs in preventive maintenance; C_F is shutdown cost of the breakdown maintenance caused by emergency, which involve the loss of shutdown caused by maintenance time and waiting time and other costs cannot be excepted to; M_T is the average interval time of preventive maintenance between faults; M is the average working time of the maintenance object; T_r is the average time that replacement needs.

According to the relations among each characteristic values of reliability [16], there are

$$M = \int_0^\infty t f(t)dt = \int_0^\infty R(t)dt \tag{3}$$

$$M_T = \int_0^T t f(t)dt = \int_0^T R(t)dt - TR(T) \tag{4}$$

If $C(T_s)$ is the average maintenance cost per time unit of time maintenance mode whose replacement cycle is T_s (including replacement cost, shutdown loss, management cost). $C(T_d)$ is the average maintenance cost per time unit of condition maintenance mode.

For timing maintenance mode, by Eqs. (1) and (3), there is:

$$C\left(T_s\right) = \frac{C_0 + C_{E1} + C_F\left[1 - R\left(T_s\right)\right]}{T_r + \int\limits_0^{Ts} R(t)dt - T_s R\left(T_s\right)} \tag{5}$$

In the equation, C_{E1} is the planning management cost of condition maintenance mode.

Similarly, for condition maintenance mode, by Eqs. (1) and (3), there is:

$$\begin{aligned} C\left(T_d\right) &= \frac{C_0 + \sum\limits_{i=1}^{n} \int\limits_{t_{i-1}}^{t_i} C_i dt + C_F \sum\limits_{i=1}^{n} \int\limits_{t_{i-1}}^{t_i} f(t)dt}{T_r + M_T} \\ &= \frac{C_0 + \sum\limits_{i=1}^{n} \int\limits_{t_{i-1}}^{t_i} C_i dt + C_F \sum\limits_{i=1}^{n} \left[R\left(t_{i-1}\right) - R\left(t_i\right)\right]}{T_r + \int\limits_0^{t_n} R\left(t_n\right) dt - t_n R\left(t_n\right)} \\ &= \frac{C_0 + \sum\limits_{i=1}^{n} \int\limits_{t_{i-1}}^{t_i} C_i dt + C_F\left[1 - R\left(t_n\right)\right]}{T_r + \int\limits_0^{t_n} R\left(t_n\right) dt - t_n R\left(t_n\right)} \end{aligned} \tag{6}$$

In the equation, t_0 is the initial run time of maintenance object; $t_1, t_2, \ldots, t_i, \ldots, t_n$ is the periodic inspection time of condition maintenance; t_n is the maintenance time; C_i is the average detection cost and planning management cost of periodic inspection in every cycle; $f(t)$ is the fault density function of maintenance object.

At this moment, the problem of tradeoff can be come down to the comparison of preventive maintenance cost $C(T_s), C(T_d)$ and breakdown maintenance cost C_∞. When $C(T_s) < C_\infty, and\ C(T_s) < C(T_d)$, that is timing maintenance cost is smaller than breakdown maintenance cost and condition maintenance cost, which means that timing maintenance mode is worthwhile, so time maintenance mode should be adopted; when $C(T_d) < C_\infty, and\ C(T_d) < C(T_s)$, that is condition maintenance cost is smaller than breakdown maintenance cost and timing maintenance cost, which means that condition maintenance mode is worthwhile, so condition maintenance mode should be adopted; when $C_\infty < C(T_s), and\ C_\infty < C(T_d)$ that is breakdown maintenance cost is smaller than preventive maintenance cost, which means that breakdown maintenance mode is worthwhile, so breakdown maintenance mode should be adopted.

2.3 The Improvement Analysis of D-Logic Decision Model Compared to Traditional Logic Decision Model

Compared with other tradition models, the D-logic decision model has its characteristics, and their differences are shown in the following aspects.

In the logic relation of maintenance modes selection, from the point of breakdown maintenance and preventive maintenance, the D-logic decision model bases on the application scope and characteristics of every maintenance mode, makes safety, environment and economic as the common decision and selection limited conditions of timing maintenance, condition maintenance and improvement maintenance, and then, according to the technical feasibility and effectiveness, select the preventive maintenance mode. The changing of decision and selection limited conditions can not only guarantee the reliability-based maintenance mode selection principle, but also avoid the plenty of repetition in traditional logic decision graph.

In the economic guarantee, the D-logic decision model considers further the economic comparison on different preventive maintenance modes under the condition that all techniques are feasible. The economic effect differences not only exist in preventive maintenance and breakdown maintenance, but also exist in different preventive maintenance. So, when select maintenance mode, the comparison on preventive maintenance cost and breakdown maintenance cost should be considered, and maintenance cost among different maintenance tasks should also be considered. Then, the most economical maintenance mode can be selected. However, as for traditional models, in the decision course of ensuring maintenance mode, they only consider the cost comparison on preventive maintenance and breakdown maintenance, and do not consider the cost comparison on different preventive maintenance modes under the condition that all techniques are feasible. Therefore, in sequential decision, this preventive maintenance mode is selected as long as maintenance cost is less than the cost caused by the fault, and subsequent maintenance mode can not be judged. The result is that subsequent maintenance mode which is technical feasible and more economic can not be adopted. As for the improved decision model, it not only considers the economic reason when making decision on breakdown maintenance and preventive maintenance, but also makes economic comparison on time maintenance and condition maintenance in order to select a more economic maintenance mode, which fully reflects the concept of economic optimization in maintenance mode decision.

Moreover, the D-logic decision model increases the selection module of real-time fault and improves the managerial flexibility of maintenance mode. Any predetermined maintenance mode can check the random faults of maintenance object absolutely, and when the random faults appear, there also exists a course of matching selection of maintenance mode.

In addition, the D-logic decision model increases the course of collecting and analyzing data newly. to the case that predetermined maintenance mode can not found, which is caused by the limitation of existing maintenance theory and technical condition or inadequate data and wrong analysis, the data should be collected newly and analyzed again.

3 Conclusion

According to the deficiency of traditional logic decision graph, the paper contributes a developed logic decision model of maintenance mode allocation. As the model avoids plenty of repeat in traditional logic graph, considers further the economic comparison of different maintenance modes under the condition of technical feasibility, and increases maintenance mode selection module of timing maintenance and the course to collect and analyze data newly, it has the characteristics of rapid, economic assurance and applicability. In addition, the economic tradeoff strategy proposed considers the cost calculation differences between condition maintenance and timing maintenance; therefore, it conforms to reality better than others.

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Customer Group Dividing for Product Platform

Wen-yan Zhao, Su-na Chen, and Xiao-fang Xi

Abstract The main purpose of applying fuzzy clustering method to dividing customer group is to divide series or establish serial platform, satisfying customer demand and promoting the robustness of product platform. Aiming at the deficiencies of current customer group dividing method based on fuzzy clustering, in this paper, an improved customer group dividing method based on fuzzy transitive closure dynamic clustering method is presented and a method to find the same result elements is adopted to simplify the calculation process of the transitive closure of a fuzzy similar matrix. And then, based on customer group dividing result, a product platform model based on customer group dividing is established in order to improve products based on platform. Finally, an instance of A electronic company manufacturing speakers is given in order to verify the effectiveness of the method proposed.

Keywords Customer group • Fuzzy clustering • Fuzzy transitive closure • Product platform

1 Introduction

Nowadays, the great challenge enterprises facing is to provide personalized products to meet customer demand with the least cost, the shortest period and the fewest product diversification. Then, the enterprises have adopted an effective way of mass customization to achieve, that is product platform, and derive a series of product variants based on product platform. Product platform can be defined as the set of a series of general elements which share potential core technology (parts, components

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and process, etc.), and product platform based on a series of derivatives can be effectively developed and constructed [1]. Product platform is the basis of product family, and product family can be developed based on product platform. Product family is a series of products meeting different customer demand, which share a product platform, but possess different properties and characteristics [2].

The main function of distinguishing customer group is to establish a series of product platform, and then, derive product variants from every platform to meet customer groups with similar demand. Product development based on product platform not only meets the maximization of the commonalities between products, simplifying the process of design and production, but also satisfies individual demand of different customers. Whether the division of customer group is accurate or not, to some extent, it determines the robustness of product platform.

Zhu Lingyun [3] in his doctoral dissertation combined fuzzy set theory with clustering analysis, proposing a customer demand group clustering method based on triangular fuzzy number to classify customer groups with mixed attributes. Yue Tongqi [4] has put forward a customer group clustering method based on fuzzy theory, meanwhile, he has also gave a simulated annealing algorithm to perform customer group dividing in the process of product family formation. G.T.S. Ho etc. [5] has proposed a robust genetic algorithm based on k-means clustering to perform customer group dividing. Jiuh-Biing Sheu [6] has proposed a comprehensive fuzzy optimum customer group dividing method based on logistics technology so that they could swiftly respond to a series of customer demand. Dai Z H [7] has proposed a hierarchy clustering analysis method in order to conduct clustering analysis for customer demand based on sensitivity analysis, optimizing the number of product variant.

In this paper, the method to find the same result elements is applied to simplifying the calculation process of the transitive closure in dynamic clustering method based on fuzzy transitive closure. And the dynamic clustering method based on fuzzy transitive closure is used to classify customer group [5, 8]. On the basis of this, we establish a product platform model based on customer group dividing in order to improve products or develop new products in term of the platform and guarantee the robustness of platform from the root, satisfying customers' individual demand.

2 Dynamic Clustering Method Based on Fuzzy Transitive Closure

2.1 The Related Concepts of Fuzzy Transitive Closure Dynamic Clustering Method

The literature [9, 10] give related concepts of fuzzy transitive closure dynamic clustering method, they are as follows:

Definition 1 Fuzzy Relation and Its Nature Given two universes, that is *X, Y*, fuzzy subset $\tilde{R}$ among their direct product space $X \times Y = \{(x,y)|x \in X, y \in Y\}$ is called a binary relation in $X \times Y$, abbreviated fuzzy relation $\tilde{R}$. For $x \in X, y \in Y$, the membership function of fuzzy relation $\tilde{R}$ is determined by mapping

$$\mu_{\tilde{R}}(x, y) : X \times Y \to [0, 1] \tag{1}$$

The membership $\mu_{\underset{R}{\sim}}(x, y)$ demonstrates the degree of *x* and *y* having the relation R̃, abbreviated $\tilde{R}(x, y)$. The fuzzy relation on universe *X* to *X* is referred to as fuzzy relation on universe *X*.

Assuming $\tilde{R}$ is a fuzzy relation on universe *X*, thus, we draw the nature of fuzzy relation: (1) Reflexivity (2) Symmetry (3) Transitivity

Definition 2 Fuzzy Matrix If universe *X* and *Y* are finite universes, that is $X = \{x_1, x_2, \ldots, x_m\}$, $Y = \{y_1, y_2, \ldots, y_n\}$, then fuzzy relation $\tilde{R}$ in can be expressed as

$$\tilde{R} = \left(r_{ij}\right)_{m\times n}, \mathrm{r_{ij}} = \mu_{\underset{R}{\sim}}\left(\mathrm{x_i}, \mathrm{y_j}\right) \quad \left(\mathrm{r_{ij}} \in [0, 1]\,, and, \mathrm{i} = 1, 2, \ldots \mathrm{m}; \mathrm{j} = 1, 2, \ldots, \mathrm{n}\right) \tag{2}$$

Now, we refer to matrix $\tilde{R}$ as a fuzzy matrix.

Definition 3 λ-cut Matrix of Fuzzy Matrix $\tilde{R}$ Given fuzzy matrix $\tilde{R} = \left(r_{ij}\right)_{m\times n}$, for any $\lambda \in (0,1)$, we refer to

$$\widetilde{R_\lambda} = \left({r^{(\lambda)}}_{ij}\right)_{m\times n} \left({r^{(\lambda)}}_{ij} = \begin{cases} 1, when \;\; r_{ij} \geq \lambda \\ 0, when \;\; r_{ij} \leq \lambda \end{cases}\right) \tag{3}$$

as λ-cut matrix of fuzzy matrix $\tilde{R}$.

Definition 4 Fuzzy Equivalent Relation and Fuzzy Equivalent Matrix Assuming $\tilde{R}$ is a fuzzy relation on *X*, if $\tilde{R}$ also has reflexivity, symmetry and transitivity, then $\tilde{R}$ is a fuzzy equivalent relation; when $\tilde{R}$ is a fuzzy matrix on *X*, that is $\tilde{R} = \left(r_{ij}\right)_{n\times n}$, at the same time, it satisfies reflexivity, symmetry and transitivity, then, $\tilde{R}$ is called a fuzzy equivalent matrix.

Definition 5 Transitive Closure The transitive closure $t\left(\tilde{R}\right)$ of fuzzy relation $\tilde{R}$ is

$$t\left(\tilde{R}\right) = \tilde{R} \cup \tilde{R}^2 \cup \ldots\ldots \cup \tilde{R}^m \cup \ldots\ldots = \bigcup_{m=1}^{\infty} \tilde{R}^m \tag{4}$$

Because

$$t\left(\tilde{R}\right)^2 = t\left(\tilde{R}\right) \circ t\left(\tilde{R}\right) = \tilde{R}^2 \cup \tilde{R}^3 \cup \ldots\ldots \tag{5}$$

$t\left(\tilde{\mathrm{R}}\right) \circ \mathrm{t}\left(\tilde{\mathrm{R}}\right) \subseteq \mathrm{t}\left(\tilde{\mathrm{R}}\right)$ can be obtained from the above two equations. From this, we can conclude that for any fuzzy relation, whether it has transitivity or not, its transitive closure always has transitivity. Therefore, we can apply transitive closure method to converting a fuzzy similar matrix into a fuzzy equivalent matrix.

2.2 Customer Group Dividing Steps Based on Fuzzy Transitive Closure Dynamic Clustering Method

Suppose $X = \{x_1, x_2, \ldots, x_n\}$ is entire customers to be clustered, customer demand for each customer is characterized by m characteristics, that is $(x_{i1}, x_{i2}, \ldots \ldots, x_{im})$, thus the matrix of entire customer demand of customers to be classified is obtained:

$$\begin{bmatrix} x_{11} & x_{12} & \ldots\ldots & x_{1m} \\ x_{21} & x_{22} & \ldots\ldots & x_{2m} \\ x_{i1} & x_{i2} & \ldots\ldots & x_{im} \\ \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots \\ x_{n1} & x_{n2} & \ldots\ldots & x_{nm} \end{bmatrix} \tag{6}$$

1. Normalize customer demand data

Before customer group dividing, this paper adopts mean normalization to normalize customer demand data.

That is

$$x'_{ij} = \frac{x_{ij}}{\bar{x}_j}, among\ \bar{x}_j = \frac{1}{n}\sum_{i=1}^{n} x_{ij} \tag{7}$$

2. Establish a fuzzy similar matrix

After completing normalizing customer demand data, this paper adopts Euclidean distance to calculate the similarity between customer demands.

$$\begin{gathered} r_{ij} = \begin{cases} 1, i = j \\ 1 - C\sqrt{\sum_{k=1}^{m} \left(x_{ik} - x_{jk}\right)^2}, i \neq j \end{cases}, \\ amongC = \frac{1}{\max\left(\sqrt{\sum_{k=1}^{m} \left(x_{ik} - x_{jk}\right)^2}\right)} \end{gathered} \tag{8}$$

i, j are the serial number of customer demand of customers to be clustered.

After calculating out r_{ij}, thus, we obtain a fuzzy similar matrix

$$\tilde{R} = \begin{bmatrix} r_{11} & r_{12} & \cdots\cdots & r_{1n} \\ r_{21} & r_{22} & \cdots\cdots & r_{2n} \\ r_{i1} & r_{i2} & \cdots\cdots & r_{in} \\ \cdots\cdots & \cdots\cdots & \cdots\cdots & \cdots\cdots \\ r_{n1} & r_{n2} & \cdots\cdots & r_{nn} \end{bmatrix} \tag{9}$$

3. Use the transitive closure method to convert a fuzzy similar matrix into a fuzzy equivalent matrix [11]

The fuzzy similar matrix satisfies reflexivity and symmetry, but it does not satisfy transitivity. Therefore, we need to use the transitive closure method to convert it into a fuzzy equivalent matrix. In order to simplify the calculation process, we use a simple method of transitive closure to solve the transitive closure of a fuzzy similar matrix, finding out the representative element of $\tilde{R}$ (the n − 1 largest elements found out in $\tilde{R}$ are all called representative element group of $\tilde{R}$, and each element of them is called representative element of $\tilde{R}$) and selecting the same result elements of some representative elements of $\tilde{R}$, thus, we can directly write out transitive closure $t(\tilde{R})$.

The simple algorithm steps of the transitive closure of fuzzy similar matrix $\tilde{R}$ [12]:

Denote $\tilde{R} = [r_{ij}]$ and $t(\tilde{R}) = [r_{ij}{}^*]$, then

(i) If r_{ij} is a representative element of $\tilde{R}$, then $r_{ij}{}^* = r_{ij}$;
(ii) If r_{ij} is a same result element of r_{kl}, then $r_{ij}{}^* = r_{kl}$.

Therefore, we give a directly solving method of $t(\tilde{R})$:

(a) Find out representative elements of $\tilde{R}$;
(b) Select the same result elements of some representative elements of $\tilde{R}$;
(c) Write out $t(\tilde{R}) = [r_{ij}{}^*]$. Among,

$$r_{ij}{}^* = \begin{cases} r_{ij}, & \text{when } r_{ij} \text{ is a representative element of } \tilde{R} \\ r_{kl}, & \text{when } r_{ij} \text{ is not a representative element of } \tilde{R} \end{cases}$$

Here, r_{kl} is a standard element of a unrepresentative element of $\tilde{R}$ (If a representative element of $\tilde{R}$ has a same result element, then we refer to this representative element as a standard element of its same element.).

4. Apply F statistics method to selecting optimal threshold λ, solving λ-cut matrix of the transitive closure [13]. Given one $\lambda \in [0,1]$, correspondingly, we can obtain one R_λ. Suppose when $r_{ij} \geq \lambda$, then $r_{ij} = 1$; when $r_{ij} \leq \lambda$, then $r_{ij} = 0$, therefore, we can get cut matrix $R_{\lambda.}$

5. According to optimal threshold λ selected, we can obtain customer group dividing result [14].

3 The Instance of Customer Group Dividing for Product Platform

3.1 Customer Group Dividing Based on Fuzzy Transitive Closure Dynamic Clustering Method

Aiming at speakers manufactured by A electronics company, we regard five customer demand parameters as indicators of clustering analysis and select five customers for their customer requirements to adopt fuzzy clustering method to perform customer group dividing.

Clear sound and no noise W1: (1) sweet (2) cordial (3) clear (4) general
Characteristic sensitivity W2: (1) very high (2) high (3) general (4) low
Appearance W3: (1) neat appearance (2) clear mark (3) riveting well (4) welding well
Rated impedance W4: (1) 4 Europe (2) 8 Europe (3) 16 Europe (4) 32 Europe
Reliability under long-term use and harsh environment W5: (1) less than 6 months (2) 6 months to 1 year (3) more than 1 year (4) more than 1 year and a half

Five customers select speakers according to their own needs, specific customer demand data is shown in Table 1.

Table 1 Customer demand data table

Demand project / Customer	Clear sound and no noise (x_{i1})	Characteristic sensitivity (x_{i2})	Appearance (x_{i3})	Rated impedance (x_{i4})	The reliability under long-term use and harsh environment (x_{i5})
x_1	2	3	2	1	3
x_2	1	2	3	1	3
x_3	3	3	3	2	4
x_4	4	2	4	3	1
x_5	3	4	2	2	1

Customer demand data normalized by Mean normalization (see formula (7)) can be expressed as a form of matrix X:

$$X = \begin{bmatrix} 0.7692 & 1.0714 & 0.7143 & 0.5556 & 1.2500 \\ 0.3846 & 0.7143 & 1.0714 & 0.5556 & 1.2500 \\ 1.1538 & 1.0714 & 1.0714 & 1.1111 & 1.6667 \\ 1.5385 & 0.7143 & 1.4286 & 1.6667 & 0.4167 \\ 1.1538 & 1.4286 & 0.7143 & 1.1111 & 0.4167 \end{bmatrix}$$

Using Euclidean distance formula (8), we can calculate the coefficient of similarity between customers to be classified, obtaining the degree of similarity between individual customer demands, thus, we can obtain fuzzy similar matrix $\tilde{R}$ of customers to be clustered.

$$\tilde{R} = \begin{bmatrix} 1 & 0.6551 & 0.5271 & 0.0345 & 0.3857 \\ 0.6551 & 1 & 0.4045 & 0 & 0.1883 \\ 0.5271 & 0.4045 & 1 & 0.1807 & 0.2676 \\ 0.0345 & 0 & 0.1807 & 1 & 0.3397 \\ 0.3857 & 0.1883 & 0.2676 & 0.3397 & 1 \end{bmatrix}$$

Fuzzy similar matrix $\tilde{R}$ satisfies reflexivity and symmetry, but it does not satisfy transitivity. Therefore, we need to solve the transitive closure of the fuzzy similar matrix, converting a fuzzy similar matrix into a fuzzy equivalent matrix.

Apply directly solving method of $t(\tilde{R})$ to calculating the transitive closure of the fuzzy similar matrix:

$$t\left(\tilde{R}\right) = \begin{bmatrix} 1 & 0.6551 & 0.5271 & 0.3397 & 0.3857 \\ 0.6551 & 1 & 0.5271 & 0.3397 & 0.3857 \\ 0.5271 & 0.5271 & 1 & 0.3397 & 0.3857 \\ 0.3397 & 0.3397 & 0.3397 & 1 & 0.3397 \\ 0.3857 & 0.3857 & 0..3857 & 0.3397 & 1 \end{bmatrix}$$

Thus, a fuzzy equivalent matrix $R^* = t\left(\tilde{R}\right)$ is obtained.

After getting the fuzzy equivalent matrix, we select any $\lambda \in [0,1]$, obtaining cut matrix R_λ, R_λ is a division of X. Sequentially, $\lambda = 1, 0.6551, 0.5271, 0.3857, 0.3397$ is taken, correspondingly, cut matrix R_λ is got. Furthermore, we successively obtain five different customer group dividing results $\{x_1\},\{x_2\},\{x_3\},\{x_4\},\{x_5\};\{x_1,x_2\},\{x_3\},\{x_4\},\{x_5\};\{x_1,x_2,x_3\},\{x_4\},\{x_5\};\{x_1,x_2,x_3\},\{x_4\},\{x_5\};\{x_1,x_2,x_3,x_4,x_5\}$.

For the classification scheme corresponding to each threshold λ, F statistics method is adopted to calculate F value, and confidence $\alpha = 0.05$ is given. From F critical value table, we can check out critical value $F_{0.05}$ of customer group classification. Thus, the optimal threshold value is $\lambda = 0.6551$, accordingly, the optimal classification scheme of customer group is $\{x_1,x_2\},\{x_3\},\{x_4\},\{x_5\}$.

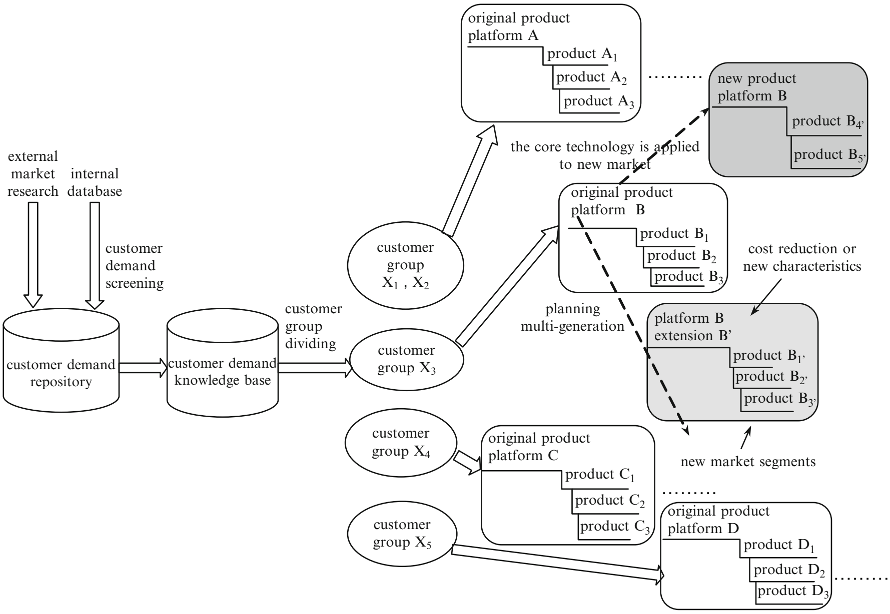

Fig. 1 The product platform model based on customer group dividing of A electronic company

3.2 The Establishment of Product Platform Model Based on Customer Group Dividing

Based on the customer group dividing method proposed by this paper, a related product platform model is established (as shown in Fig. 1).

Through the product platform constructed based on customer group dividing, the electronic company can improve or develop new products based on platform, avoiding unnecessary design and process changes. In the meanwhile, we can reduce cost or form new characteristics, meeting personalized customer demand and increasing customer satisfaction.

4 Conclusion

In this paper, we are on the ground of product platform and customer demand dividing research achievements, having simplified the calculation process of the transitive closure of a fuzzy similar matrix. The customer group dividing result is applied to establishing a product platform model based on customer group dividing and some guidance is provided for enterprise's designers to improve products based on product platform. But this paper only simplifies the calculation process of dynamic clustering method based on fuzzy transitive closure proposed in the process of customer group dividing. However, looking for a more appropriate fuzzy clustering algorithm for customer group dividing and improving product platform model based on customer group dividing deserve our further study.

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Study on the Relationship Between Local Government Behavior and the Differences of Regional Financial Development

Hai-bing Wu, Xiao Tang, and Yan-qiong Zhou

Abstract Taking eastern, central and western regions as basis for classification, and using relevant data from 1986 to 2010, through the fluctuation of the index of financial revenue and expenditure gap ratio, this article firstly proves China's local government behavior of financial intervention is the objective existence; then through regression analysis of per capita GDP, which is the quantitative indicators of the local government behavior, and financial interrelation ratio(FIR), which is the indicators of the degree of financial development, this article studies the extent and impact of the three regions' government intervention; Thereafter, to test the causal relationship between government behavior and regional financial development in the three regions by Granger test; further, by using the impulse response function, the article analyzes the influence of local government behavior on the region's financial development level. The study found that the formation of China's regional financial difference is not driven by market factors; government intervention occupies a crucial position in various factors of the formation of regional financial development's difference.

Keywords Regional finance • Local government behavior • Institutional arrangement

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1 Introduction

Our country has experienced the transformation from the planned economy to the socialist market economy with Chinese characteristics. With the changes of system and the government preference policy, the development of regional economic shows different characteristics [1]. The course of China's regional financial development has experienced two significant stages, which from balanced to unbalanced. Based on the special nature of the transition economies, the differences of development of China's regional financial depend more on the government's arrangements of external institutional. Regional differences in financial development have strong externalities, the central government and the local government behavior plays a crucial role in the development process of regional financial.

The current domestic academic research on regional economic and financial differences mainly focus on the differences of the level of regional financial development and the relationship between regional economic and regional finance, such as regional economic theory, financial geography and financial development theory. A large number of research results showed the endogenous relations between the regional economic growth and regional financial development, and various factors leading to the unbalance of financial development from the perspective of geography, spatial economics, and macro economy [2]. However, because excessive emphasis on geography, space environmental factors, as well as the ideal market economy conditions, scholars largely ignored the impact of government intervention in the environment, and are unable to provide support of system theory for the actual work. This article attempts to explore the influence of government institutional arrangements on the differences of regional financial development. Through Granger causality test and data regression model, the inherent causality between the local government and regional financial differences of the three economic blocks will be analyzed. And then effective policy recommendations will be proposed to achieve the harmonious development of the regional finance.

2 Effects of Local Government Behavior on the Formation of Regional Financial Difference

With the deepening of China's market economy reform, after the decentralization reform, local government's financial resources and financial powers increase greatly and economic strength has been further enhanced. Because the local government is relatively independent of the interests and rights, the central government lost its leading status of financial resource allocation; various resources begin to shift to the local government and the market. In the early stages of development, China's economic growth is also very extensive [3]. The speed of economic development mainly depends on the input of large-scale of factors and the possession of resources. This inherent mechanism determines that how much economic benefit the local governments can obtain directly depends on how many resources they can possess and how much right they owned to allocate.

After the implementation of call loan and transfer loan, finance has become the core channels of the formation and accumulation of various regions' capital [4]. However, because of the changes in the financial system, financial institutions have policy endowment of allocating capital. Since the t financial constraints of central government, the state-owned banks cannot satisfy all the regional economic development. And local government's focus has turned to the financial sector; through the establishment of relevant institutions of their financial system, financial institutions trend to increase the way of obtaining funds for local [5]. Because of the establishment of local financial institutions, the number of financial institutions and the scale of financial recourses controlled by developed provinces have expanded on an unprecedented scale. At this time, competition for financial resources centering on the difference of the local government' finance system arrangement has become the non-cooperation game between local governments and central government and the zero-sum game between various local governments [6]. Thus, the change of the differences in the development of regional financial in china is a gradual process of institutional change. Among them, the central government institution, local government, and the main body of the market economy has played a leading role successively.

Relying on political influence and the ability to control economy, local governments ask central government for the preferential policies to strive for the best resources for themselves. For example, since Hainan was promoted to the special economic zones, the relevant preferential policies of the state make the number and density of financial institutions here increased dramatically. Promoted by the government of Hainan, the province was about ten billion of gross domestic product, has set up 22 companies, with an average of 3,000 people with a financial institution [7]. Excessive expansion of the number and the scale of financial institutions and disorderly competition in the industry led to the increased financial risk. Ultimately Hainan was in the final of the economic bubble burst.

If local financial revenue and expenditure gap ratio indicates the degree of administrative intervention, the larger the value of gap ratio expressed the degree of intervention is stronger; contrary the degree of intervention is weaker. Table 1 shows the financial revenue and expenditure gap ratio of 12 western provinces (autonomous regions) was significantly higher than that of the 10 eastern provinces; especially the ratio of financial revenue and expenditure gap in Tibet is the highest. All the Information in the table is collected from "China Statistical Yearbook" and "China regional financial operation report". The average ratio of financial revenue and expenditure gap of China's western region is 14.11 %, is about 35 times of that in the eastern region. This proves that western region has the highest level of administrative intervention.

Where:

Financial revenue and expenditure gap ratio = financial revenue and expenditure gap/general budget revenue of local finance

Table 1 Financial revenue and expenditure gap ratio of China's 31 provincial-level administrative regions (UNIT: %)

Year / Region	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Beijing	0.28	0.23	0.18	0.24	0.21	0.15	0.16	0.23	0.06	0.14	0.15
Tianjin	0.40	0.43	0.54	0.53	0.52	0.33	0.30	0.38	0.57	0.36	0.29
Hebei	0.67	0.81	0.91	0.93	0.93	0.90	0.90	1.25	0.96	1.20	1.12
Shanxi	0.97	1.18	1.22	1.23	1.02	0.82	0.57	1.11	0.76	0.94	0.99
Inner Mongolia	1.60	2.21	2.49	2.22	1.87	1.46	1.37	1.59	0.31	1.26	1.12
Liaoning	0.75	0.72	0.73	0.75	0.76	0.78	0.74	0.88	0.59	0.69	0.59
Jilin	1.51	1.70	1.76	1.66	2.05	2.05	1.93	2.20	1.79	2.04	1.97
Hei-longjiang	1.06	1.24	1.29	1.27	1.41	1.48	1.50	2.08	1.67	1.93	1.98
Shanhai	0.25	0.16	0.22	0.23	0.25	0.16	0.14	0.14	0.20	0.18	0.15
Jiangsu	0.32	0.28	0.34	0.31	0.34	0.27	0.22	0.34	0.17	0.24	0.20
Zhejiang	0.26	0.19	0.32	0.27	0.32	0.19	0.13	0.29	0.33	0.24	0.23
Anhui	0.81	1.10	1.28	1.30	1.19	1.13	1.20	1.65	1.24	1.48	1.25
Fujian	0.38	0.36	0.46	0.48	0.55	0.37	0.35	0.53	0.54	0.51	0.47
Jiangxi	1.00	1.15	1.43	1.27	1.21	1.23	1.28	1.70	1.47	1.69	1.47
Shandong	0.32	0.32	0.41	0.42	0.44	0.37	0.35	0.60	0.38	0.49	0.51
Henan	0.81	0.90	1.12	1.12	1.05	1.08	1.12	1.58	1.26	1.58	1.47
Hubei	0.72	1.09	1.10	1.08	1.08	1.07	1.20	1.54	0.22	1.57	1.47
Hunan	0.96	1.10	1.31	1.14	1.24	1.21	1.23	1.66	1.72	1.61	1.50
Guang-dong	0.19	0.14	0.27	0.29	0.31	0.27	0.17	0.32	0.34	0.19	0.20
Guangxi	0.76	0.97	1.25	1.18	1.13	1.16	1.13	1.82	1.48	1.61	1.60
Hainan	0.64	0.80	1.00	1.05	1.23	1.20	1.13	1.68	1.41	1.72	1.14
Chong-qing	0.93	1.24	1.43	1.11	0.97	0.90	0.87	0.99	0.75	0.97	0.80
Sichuan	1.15	1.19	1.40	1.18	1.32	1.26	1.22	1.45	1.85	2.06	1.73
Guizhou	1.36	1.76	1.92	1.67	1.80	1.85	1.69	2.31	2.01	2.29	2.06
Yunnan	1.29	1.60	1.55	1.56	1.52	1.45	1.35	1.72	1.39	1.80	1.62
Tibet	10.14	16.11	17.86	16.90	12.36	14.41	12.75	15.70	14.30	14.62	14.04
Shaanxi	1.36	1.58	1.69	1.36	1.40	1.32	1.27	1.62	1.60	1.50	1.32
Gansu	2.07	2.37	2.59	2.42	2.43	2.48	2.74	3.12	1.05	3.35	3.15
Qinghai	3.12	4.11	4.63	4.08	4.09	4.02	4.08	5.00	1.67	4.55	5.74
Ningxia	1.92	2.39	3.33	2.52	2.28	2.36	2.15	2.50	2.40	2.88	2.63
Sinkiang	1.41	1.77	2.10	1.87	1.70	1.88	2.09	2.30	1.93	2.46	2.39

From 2000 to 2010, China's provincial fiscal gap ratio differences in changes. Fiscal gap ratio of various provinces shows an overall polynomial increasing trend, but the volatility is still evident. Especially the expanding multiples of the extremum ratio in 2002, 2005 and 2008 are amazing. Especially in 2008, the extremum ratio has reached to 221.34. The remaining ratios are no less than 30 times. It proves that the changes in the ratio of financial revenue and expenditure gap of China's provinces is different significantly, indicating that the extent of local government intervention in the financial is not the same. From the variation coefficients, the difference is relatively small, but in view of the rate of increase, the highest rate of increase has reached more than 30 %. Moreover, there is a large fluctuation in the trend curve of the ratio; it also indicates that China's local government behavior on financial intervention is different.

From Fig. 1, it can be seen that financial revenue and expenditure gap ratio and financial correlation ratio of China's provinces and autonomous regions has strong correlations. Panel data analysis indicates that the higher the ratio of fiscal revenue and expenditure gap provinces, the lower its financial ratio, each other presents the trend of diminishing. From the add trend line, the fiscal revenue and expenditure gap ratio and the related financial ratios fit more closely. It proves that local government behavior has significant influence on the difference of regional financial development.

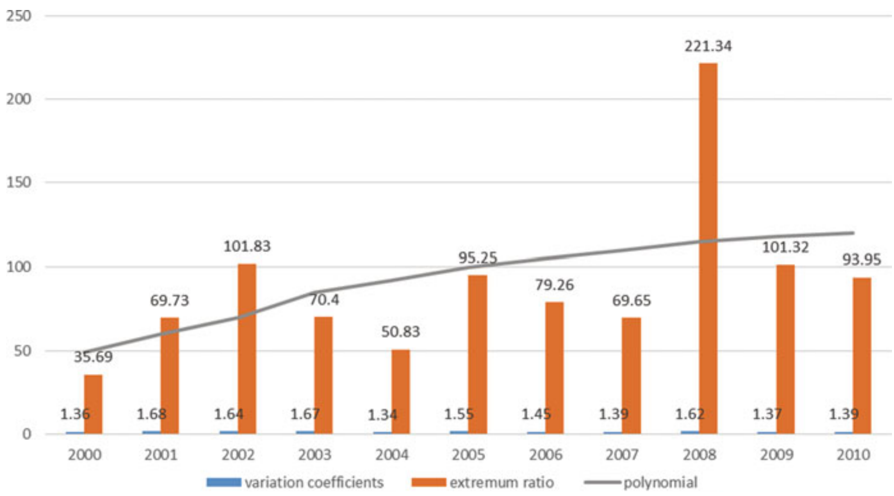

Fig. 1 The trend of the variation coefficients and extremum ratio of various provinces' financial revenue and expenditure gap ratio during 2000 to 2001 (*Information source*: Collect from "China Statistical Yearbook" (1990–2010); "China Financial Yearbook" (1999–2010))

3 Empirical Analysis

3.1 Selection of Indicators and Data Sources

Since the reform and opening up, for economic development, local governments with the individual interests actively participate in the game between local governments, and have strong desire to control the financial resources. This part tries to make a quantitative analysis of government behavior, so as to better measure the relationship between local government behavior and regional financial development. Excluding the impact of historical, cultural and other factors, the behavior of the local government directly determines a financial development level. Therefore, the regional per capita GDP can be used as the quantitative indicators of the government behavior, and the FIR (financial interrelation ratio) can be used as a measure of regional financial index.

Considering the data availability and issues related to the measurement data processing (such as China's FIR in 1986 was less than 1, which results the logarithmic smoothing processing cannot be carried out directly), the time span of this study is from 1986 to 2010, and the main sources of basic data needed are "regional financial operation report" (2004–2010), "China Financial Yearbook" (1993–2010), "China Statistical Yearbook" (1986–2010) "compilation of statistical data of fifty-five years of new China".

3.2 Model Constructing

On the issue of constructing model, this article regards the government behavior as an explanatory variable (per capita GDP of the four regions, respectively expressed by GDP1, GDP2, and GDP3), and regards the regional financial development as explanatory variables (level of financial development of the three regions respectively represented by FIR1, FIR2, and FIR3) through the use of a first-order regression, equation is as follows:

$$\mathrm{LN\,(FIRt)} = \mathrm{a0} + \mathrm{a1\ LN\,(GDPt)} + \mathrm{ut}$$

Regression according to relevant data, four regional per capita GDP and the data of per capita deposit and loan tends to be stable; a long-term stable linear combination exists in four regions. Through the regression of data corresponding to the four regions with SPSS software, the standard regression equations are respectively shown as follow:

$$\begin{array}{l}
\text{Eastern region}: \\
\mathrm{LN\,(FIR1)} = -1.28 + 0.21\mathrm{LN\,(GDP1)} \\
\text{t value}: \qquad -6.898, \quad 10.404; \\
\text{prof}: \qquad\quad 0.000 \quad\ \ 0.000 \\
\mathrm{R2} = 0.825; \mathrm{F} = 108.251 \\
\text{Central region}: \\
\mathrm{LN\,(FIR2)} = -0.85 + 0.15\mathrm{LN\,(GDP2)} \\
\text{t value}: \qquad -5.266, \quad 8.288; \\
\text{prof}: \qquad\quad 0.000 \quad 0.000 \\
\mathrm{R2} = 0.750; \mathrm{F} = 68.706 \\
\text{Western region}: \\
\mathrm{LN\,(FIR3)} = -0.96 + 0.20\mathrm{LN\,(GDP3)} \\
\text{t value}: \qquad -6.675 \quad 11.436; \\
\text{prof}: \qquad\quad 0.000 \quad 0.000 \\
\mathrm{R2} = 0.850; \mathrm{F} = 130.784
\end{array}$$

The results of regression of the three regions show that, the government behavior of each area has significant effect on the regional financial development. For every 1 % increase in the natural logarithm of per capita GDP of the eastern part will cause the eastern region's FIR smoothing value increased by 0.21 %; for every 1 % increase in the logarithmic smoothing of per capita GDP of the central region will cause the central region's FIR smoothing value increased by 0.15 %; and the central region's FIR smoothing value increased by 0.20 %. It can be seen that the influence of eastern and western regions' government behavior on regional financial development is significantly higher than of the central region.

3.3 Granger Causality Test

The regression results show that there is a long-term stable relationship between government behavior and regional financial development in the three regions, but whether this relationship is causal relations, still needs further verification. Causality test proposed by Granger [8] and Sims [9] provides a solution to the problem. In fact, this kind of causality test is a method used to investigate whether sequence X is the causes of sequence Y.

The basic idea of Granger test is if the sequence x is Granger causes of sequence y, then the X should help to predict y. That is to say the degree of the current y explained by its own lagged values should be estimated firstly, and the introduction of x's lag should significantly increase the degree which be explained of y.

For the Granger causality test, the regression model is:

$$y_t = \sum_{i=1}^{k} a_i y_{t-1} + \sum_{i=1}^{k} \beta_i x_{t-i} + u_i$$

The original hypothesis of the test is the sequence is not the Granger reason of x(y), i.e.:

$$\beta_1 = \beta_2 = \cdots = \beta_k = 0$$

At the same time, through residual sum of squares of regression, F statistic is constructed:

$$F = \frac{(RSS_r - RSS_u)/k}{RSS_u/(T-n)}$$

If $F > F_a(k, T-n)$, then the null hypothesis is rejected. So x_t is regarded as Granger reason of y_t.

The per capita GDP and FIR of the three regions selected by this article are used to carry out Granger test of lag 2, the test results are shown in Table 2.

Granger causality test showed that there is a reciprocal causation between FIR and per capita GDP on the significance level of 1 and 5 % in western region. However, although the eastern region has pas passed the previous demonstration, and there is a positive correlation between its per capita GDP (local government behavior) and the level of development. For the eastern region, through the previous empirical analysis, it can be seen that there is a positive correlation between per capita GDP (local government behavior) and the developmental level of this region. However, it did not pass the test. The result shows that local government behavior is not a necessary factor resulting in the level of financial development of the region.

Table 2 The granger causality test results of three regions' per capita GDP and FIR

Region	Causality	Null hypothesis HO	lag	F statistic	P value
Eastern region	Per capita GDP and FIR	Per capita GDP is not the Granger cause of FIR	2	7.11541	0.0053
		FIR is not the Granger cause of per capita GDP	2	0.65376	0.5320
Central region	Per capita GDP and FIR	Per capita GDP is not the Granger cause of FIR	2	3.98659	0.0369
		FIR is not the Granger cause of per capita GDP	2	1.11343	0.0179
Western region	Per capita GDP and FIR	Per capita GDP is not the Granger cause of FIR	2	3.568	0.0123
		FIR is not the Granger cause of per capita GDP	2	4.6658	0.0526

3.4 Impulse Response Analysis of Local Government Behavior's Influence on Regional Financial Difference

In order to further research on dynamic characteristics of local government behavior's influence on regional financial difference, this paper selects impulse response function to further describe this influence. This function is mainly used to characterize the trajectory of the influence of the change or impact of each endogenous variable on its own and other endogenous variables, so as to display how other variables affected by the perturbation of a variable through model, and the feedback to itself.

According to the previous regression analysis, we describe the impact of the change of one standard deviation of per capita GDP (the quantified index of local government behavior) to the developmental level of regional finance.

$$\mathrm{LN}\,(\mathrm{FIR_t}) = \mathrm{a_{11}FIR_{t-1}} + \mathrm{a_{12}LN}\,(\mathrm{GDP_{t-1}}) + \mathrm{u_{1t}}$$
$$\mathrm{LN}\,(\mathrm{GDP_t}) = \mathrm{a_{21}FIR_{t-1}} + \mathrm{a_{22}LN}\,(\mathrm{GDP_{t-1}}) + \mathrm{u_{2t}}$$

Through the results of the impulse response shown in the following figures, it can be found that the initial influence of local government behavior on the developmental level of regional finance is weak. But with the passage of time, influence of positive pulse began to appear. Especially in the eastern region, in a period of time, the results of regression analysis showed that local government behavior begin to negatively influence the financial development. This is because in the eastern region, after enjoyed a period of preferential policies, the market-oriented economy occupies the dominant status, excessive government intervention may have a negative influence on the health of the financial sector. And the influence of the government behavior in the central and western regions on financial development gradually increased, showing the behavior of local government in the central and western regions have great rationality and development space. Especially for the central and western regions, the FIR value has been low, the related initiatives of local government still can play great roles (Figs. 2, 3, and 4).

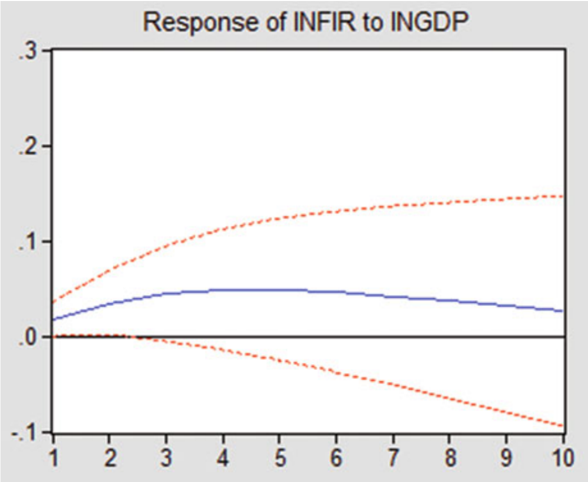

Fig. 2 The innovation response of IINFIR to one Standard deviation of INGDP in eastern region

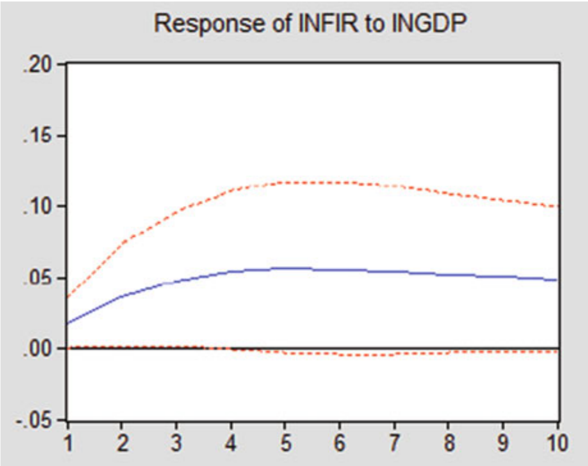

Fig. 3 The innovation response of IINFIR to one Standard deviation of INGDP in central region

3.5 Empirical Conclusions

Based on the above analysis, it can be seen that there are positive influences of various regions' government behavior on the developmental level of regional finance. But from the result of Granger test, the behavior of local government in the eastern region is not necessary reason causing the changes of financial development level. With the deepening of 20 years' market-oriented process in eastern region, influence of market mechanism on financial development may be far greater than the impact of local government intervention, even in the present situation, the negative influence of the government behavior began to appear. Granger causality existing between the local government behavior and financial development of

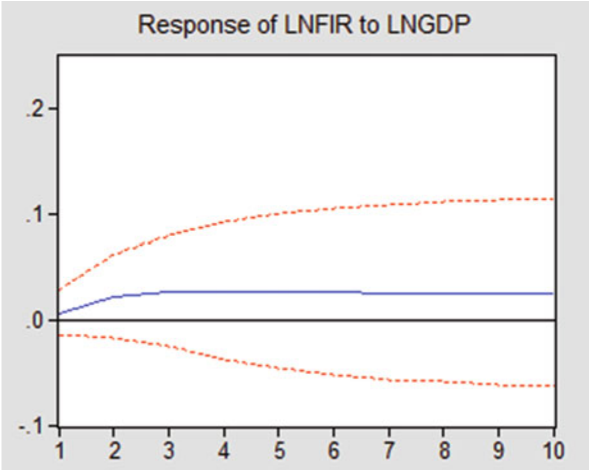

Fig. 4 The innovation response of IINFIR to one Standard deviation of INGDP in western region

central and western regions proves that the degree of government intervention of central and western regions in financial institutions directly affect the level of financial development these regions. Local government intervention can produce some direct effects: distortions of the allocation of resources of market economy, negative influence on solvency and willingness of corporations, destruction of the social culture of integrity, and so on.

After joining the WTO, because of the stimulus of the performance evaluation system, and expansionary fiscal and monetary policy of central government, through the establishment of local financing platform, local governments contract a loan to increase investment in infrastructure, so as to promote local economic development and improve the city environment, especially the real estate market. But as the government regulation of the housing market, regional hidden fiscal risk and financial risk begins to be exposed; banks, Trust Investment Company and other local financial institutions have accumulated a huge amount bad assets. Because the fiscal gap and social security funding gap are gradually widening, and the pressure of debt service is constantly enhancing, the continued accumulation of debt or fiscal risk has been a direct threat to the local financial system and economic system. Thus, in the process of the local governments' intervention, local governments will transmits the risks and mechanisms of bad assets to regional financial institutions, resulting in a decline in the quality of government departments and financial institutions' financial assets.

From the definition of government behavior, all administrative actions beyond the local public service function and reasonable intervention functions belong to the improper intervention, which will undoubtedly damage financial institutions' operating autonomy, are not conducive to the formation of effective competition mechanism and financial development environment.

4 Conclusion and Suggestion

In summary, the formation of China's difference in regional finance is not driven by market factors; government administrative intervention has played an important role in various factors of the formation of the differences in regional financial development. With the fiscal decentralization reform in 1994, investment subject is transformed from a single body, which is central government, to multiple investment bodies, which are represented by local governments. The regional financial difference mainly reflects the driven behavior of external differentiation of government to financial market.

For quite a long period of time, due to the characteristics of gradual reform and the dependence of path, differences in regional financial development under government intervention will still exist, and there will be the possibility that the gap of regional financial development will further widening [10].

We are not afraid of this gap, but should use this gap to accelerate regional financial development. China's goals of regional financial development should reflect the following characteristics: firstly, regional financial industry should adapt to the economic development of different regions and economic potential, and on the basis of their comparative advantage, regional specialization should be achieved to improve the efficiency of the allocation of financial resources; secondly, on the basis of the financial market-oriented, regional specialization should be achieved to improve the financial cooperation between the region; thirdly, establishing a regional financial center has a certain influence and radiation force. For local governments, should do the following:

Firstly, the local government should create a favorable external credit environment for the development of regional finance, and enhance the ability of self-development and innovation of economic entities and financial institutions. This is mainly reflected in the enhancement of the direct and indirect financing channels of Market-oriented within the region. The construction of regional capital market, local government can provide the trading places of property rights in the region and construct modern enterprise system for the enterprises in the area, so as to prepare for the upgrading of the industrial structure [11]. Local government also should increase the support to small and medium-sized enterprises and encourage enterprises within their jurisdiction to adopt various means for financing. The development of virtual economy, furtherance of the healthy development of securities, bonds and other financial market, and enhancement of the diversity financing channels all plays an extremely important role in developing entity economy.

Secondly, it is important to transform government functions and reduce intervention in the financial markets. In the process of positioning, the local government should put itself in a particular stage of the development of market economy and consider carefully. In fact, in the process of China's gradual reform, the excessive intervention of the local economy has caused a lot of waste of resources, and failure in allocation of financial resources [12]. With the deepening of market-oriented reform, local governments must change their functions, reduce the bank loans and the administrative guidance of investment and financing to economic agents. Let the economy as the main body of market, so as to promote the healthy development of regional finance and economy.

Finally, it is important to change the local government performance evaluation standards and promote the government reform of property rights. In the current performance appraisal system, due to the concept of "life is above everything", local governments cannot suppress the impulse to invest. Thus, some problems such as excessive credit and excessive investment are introduced. Referencing to the idea of green GDP and changing the appraisal standard, then these problems can be controlled from the source. At the same time, the local government should clear property rights to make reasonable constraints on their financial behavior.

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The Optimal Bidding Strategies Research on Multi-attribute Reverse Auction Mechanism

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Abstract In this paper, we mainly study the multi-attribute reverse auction mechanism with multiple winners. By the multi-attribute utility theory and the probability theory, we build a multi-attribute procurement model, which is more in line with reality procurement environment, and then prove the supplier's optimal bidding strategies. Moreover, we compare it with the first scoring model and conclude that, the optimal quality bidding strategies remain constant, while the optimal price bidding strategy increases with the number of the successful bidders.

Keywords Multi-attribute • Multiple winners • Reverse auction • The optimal bidding strategies

1 Introduction

With the rapid development of the economy and the Internet, auction [1] is more and more widely applied in the economic activities of enterprises. In the corporate procurement, the use of the multi-attribute auction mechanism can not only improve the efficiency of the allocation, but also reduce the procurement costs. Currently, most enterprises in the world complete their procurement by the auction. As a result, the research on procurement mechanism becomes a hot topic in the auction field. In the existed literatures on procurement, Thiel [2] gave a detailed discussion on the multi-attribute auction for the first time, and proposed that the multi-attribute procurement issue would eventually be simplified to the single attribute procurement on condition that the seller's preference function was known. Che [3] analyzed the multi-attribute auction comprehensively. He designed an auction mechanism

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considering the price and quality attributes based on the independence of enterprises costs. Branco [4] extended Che's work. He proposed an optimal multi-attribute auction mechanism in the case the enterprises costs were associated, and put forward the two-stage multi-attribute auction. Bichler [5, 6] proposed an extension model on the basis of the multi-attribute utility function method, to represent the buyers' attributes preferences with the weights of the attributes. Esther David [7] had a theoretical discussion on multiple quality attributes, and the optimal scoring rules was advanced. In addition, many other scholars [8–12] also got a lot of meaningful theoretical research results in the actual context of the procurement. They all have made important contributions to the field of the auction.

But the existed literatures are in the case of only one successful bidder. In order to further improve the adaptability of procurement auction, on the basis of the above research, this paper studies the situation there is more than one successful bidder.

2 The Auction Model and Assumptions

First, we give a general mathematical model of the auction

$$M = (B, I, A, S, U_b, U_s, W)$$

where

1. B indicates the only buyer in the market, needs to purchase raw materials. Due to the great demands, d ($d \geq 2$) suppliers working together can meet his production demands;
2. I indicates the set of the potential suppliers, denoted by $I = (1,2,\cdots,n)$;
3. A indicates the attributes space. We consider $m+1$ attributes: the price attribute p and the quality attributes $q_1, q_2, \cdots, q_m$. Then the subject can be represented by $(p,q_1,q_2,\cdots,q_m)$, which stipulates the quality standards the supplier will provide and the payment they will receive after winning;
4. S indicates the scoring rules. The buyer describes the characteristics of the raw materials and selects the optimal suppliers by it;
5. U_b, U_{si} indicate the utility functions of the buyer and supplier i respectively;
6. W indicates the set of the suppliers' final bidding status. When $w_i = 1$, which means that the supplier i wins the bid, Otherwise $w_i = 0$.

For the buyer, we introduce the value function [13] $V_b = V(q_1, \cdots, q_m)$, to show the buyer's benefits of the raw materials trading. The buyer's utility from the supplier i can be expressed as $U_{bi} = w_i(V_i(q_1, \cdots, q_m) - p_i)$, and the total utility is $U_b = \sum_{i=1}^{n} w_i \left(V_i\left(q_1, \cdots, q_m\right) - p_i\right)$; For the supplier i, we lead into the cost function $C_{si} = c_i(\theta_i, q_1, \cdots, q_m)$, where θ_i is the comprehensive cost parameters, which reflects the level of the supplier i's competence. The larger θ_i, the higher the production costs, the lower the supplier i's level. Then the utility of supplier i is $U_{si} = w_i(p_i - c_i(\theta_i, q_1, \cdots, q_m))$.

To facilitate the analysis, we give some reasonable assumptions.

1. All the participants are risk-neutral, to maximize the expected utility [14];
2. The buy's value function $V_b = V(q_1, \cdots, q_m)$ is increasing and its second-order partial derivatives function is decreasing in q_j. Correspondingly the supplier i's cost function $C_{si} = c_i(\theta_i, q_1, \cdots, q_m)$ is increasing and its second-order partial derivatives function is non-decreasing in q_j [15];
3. The supplier's cost parameters θ is independently distributed in the continuously differentiable function $F(\theta)$ during the interval $\left[\underline{\theta}, \overline{\theta}\right]$, and the corresponding density function $f(\theta)$ is the common knowledge.

Now we give a specific mathematical model satisfying the above assumptions.

1. Let $c_i\ (\theta_i, q_1, \cdots, q_m) = \theta_i \left(\sum_{j=1}^{m} b_{ij} q_{ij}\right)$ be the supplier i's cost function, where b_{ij} is i's cost parameters in q_j, then $U_{si} = w_i \left(p_i - \theta_i \left(\sum_{j=1}^{m} b_{ij} q_{ij}\right)\right)$;
2. The buyer's announcing value function is $v = \sum_{j=i}^{m} l_j \sqrt{q_j}$, where $l_j > 0$ shows the buyer's preferences for quality attributes q_j.

3 Model Analysis and Mechanism Design

The buyer pursuits of the maximization of his utility, so the announced model before the auction can be expressed as (M)

$$
\begin{aligned}
&\max_{(w_1,\cdots w_n)} U_b = \sum_{i=1}^{n} w_i \left(\sum_{j=1}^{m} l_j \sqrt{q_{ij}} - p_i\right) \\
&s.t. \\
&\begin{cases}
\sum_{i=1}^{n} w_i = d, w_i = 0, 1. i = 1, 2, \cdots n \\
U_b \geq 0 \\
U_{si} = w_i \left(p_i - \theta_i \left(\sum_{j=1}^{m} b_{ij} q_{ij}\right)\right) \geq 0, i = 1, \cdots, n
\end{cases}
\end{aligned}
\qquad (M)
$$

By the model (M), it can be seen that the bidding status w_i is non-decreasing in scoring function $S_i = \sum_{j=1}^{m} l_j \sqrt{q_{ij}} - p_i$, when $S_i > S_j$, then $w_i \geq w_j$. In order to obtain a larger score, the supplier will submit his real subjects to have more opportunity to become the successful bidder.

Proposition 1 *There is the only optimal solution for (M): according to the scoring function S, rank all the scores in descending, recorded as $s_1, s_2, \cdots s_n$, then* $\begin{cases} w_i = 1, i = 1, \cdots, d \\ w_i = 0, i = d+1, \cdots, n \end{cases}$ *is the optimal solution.*

Proof By $\sum_{i=1}^{n} w_i = d$, then $w_1 = d - \sum_{i=2}^{n} w_i$. The buyer's utility can be expressed as

$$
\begin{aligned}
U_b &= \sum_{i=1}^{n} w_i \left(\sum_{j=1}^{m} l_j \sqrt{q_{ij}} - p_i \right) \\
&= \sum_{l=1}^{n} w_l s_l = w_1 s_1 + \sum_{l=2}^{n} w_l s_l \\
&= \left(d - \sum_{l=2}^{n} w_l \right) s_1 + \sum_{l=2}^{n} w_l s_l \\
&= d s_1 - \sum_{l=2}^{n} w_l s_1 + \sum_{l=2}^{n} w_l s_l \\
&= d s_1 - w_2 (s_1 - s_2) - w_3 (s_1 - s_3) \\
&\quad \cdots - w_n (s_1 - s_n)
\end{aligned}
$$

$\because s_1 \geq s_2 \geq \cdots \geq s_n, \therefore 0 \leq s_1 - s_2 \leq s_1 - s_3 \cdots \leq s_1 - s_n$. Then the maximum value of U_b is actually equivalent to that, the addition of finite elements in the set $\{s_1 - s_l, l = 2, \cdots n\}$ is minimal, so we can conclude that the utility U_b will reach its maximum when a finite number of elements whose subscript is smaller are selected.

The proposition 1 gives the allocation rules of corporate procurement mechanism: the scores rank in descending, then the former d suppliers are the winners. The supplier with higher score will have more opportunities to win, so the mechanism is effective. The winner's subject (p,q_1,q_2, $\cdots$,q_m) provides for the payment rules: the supplier provides raw materials with the quality standards (q_1,q_2, $\cdots$,q_m) and the buyer pays the price p.

Proposition 2 *For (M), the supplier i's optimal bidding strategy in the quality attribute q_j is*

$$q_j^*\,(\theta_i) = \arg\max_{q_j} \{v\,(q_1, q_2, \cdots, q_m) - c\ (q_1, q_2, \cdots, q_m)\} \tag{1}$$

where $j = 1, 2, \cdots, m$.

Proof One would assume that, there was another subject $(p', q_1^{'}, \cdots, q_m^{'})$ for the supplier i to satisfy $U_{si}(p', q_1^{'}, \cdots, q_m^{'}) > U_{si}(p, q_1^*, \cdots, q_m^*)$, in which at least one variable $q_l^{'} \neq q_l^*, (l = 1, \cdots, m)$, and $p' = p - v(q_1^*, \cdots, q_m^*) + v(q_1^{'}, \cdots, q_m^{'})$.

Then we have

$$\begin{aligned}
U_{si}\left(p', q_1', \cdots q_m'\right) &= w_i\left[p' - c\ \left(q_1', \cdots q_m'\right)\right] \\
&= w_i\left[p - v\left(q_1^*, \cdots, q_m^*\right) + v\left(q_1', \cdots, q_m'\right)\right. \\
&\quad \left. - c\ \left(q_1', \cdots q_m'\right)\right] \\
&\le w_i\left[p - v\left(q_1^*, \cdots, q_m^*\right) + v\left(q_1^*, \cdots, q_m^*\right)\right. \\
&\quad \left. - c\ \left(q_1^*, \cdots q_m^*\right)\right] \\
&= w_i\left[p - c\ \left(q_1^*, \cdots q_m^*\right)\right] \\
&= U_{si}\left(p, q_1^*, \cdots q_m^*\right)
\end{aligned}$$

which is in contradiction to the assumptions above, so the assumption doesn't hold.

Proposition 3 *For (M), the supplier i's optimal price bidding strategy should meet*

$$p^*\,(\theta_i) = \sum_{j=0}^{d-1} P\left(I_2^j\right) p_j^*\,(\theta_i) \tag{2}$$

where $P\left(I_2^j\right) = \dfrac{\begin{pmatrix} d-1 \\ j \end{pmatrix}\begin{pmatrix} n-d+1 \\ n-d-j+1 \end{pmatrix}}{\begin{pmatrix} n \\ n-d+1 \end{pmatrix}}$

$$p_j^*\,(\theta_i) = c\left(\theta_i, q_1^*\,(\theta_i), \cdots, q_m^*\,(\theta_i)\right) + \int_{\theta_i}^{\overline{\theta}} c'\left(t, q_1^*(t), \cdots, q_m^*(t)\right)\left[\left(\tfrac{1-F(t)}{1-F(\theta)}\right)^{n-d-j}\right] dt$$

where $c'\left(t, q_1^*(t), \cdots, q_m^*(t)\right) = \frac{\partial c\left(t, q_1^*(t), \cdots, q_m^*(t)\right)}{\partial t}$ *and* $F(x) = \frac{x - \underline{\theta}}{\overline{\theta} - \underline{\theta}}$.

Proof We refer to the optimal bidding strategies in the first score procurement model [3]. Assuming there is a buyer and n suppliers in the auction, the supplier i's optimal quality and price bidding strategies is respectively denoted as $q_j^{**}(\theta_i)$, $p_j^{**}(\theta_i)$, then

$$q_j^{**}(\theta_i) = \arg\max_{q_j} \{v(q_1, q_2, \cdots, q_m) - c\ (q_1, q_2, \cdots, q_m)\},$$

$$p^{**}(\theta_i) = c\left(\theta_i, q_1^*(\theta_i), \cdots, q_m^*(\theta_i)\right) + \int_{\theta_i}^{\overline{\theta}} c'\left(t, q_1^*(t), \cdots, q_m^*(t)\right)\left[\left(\tfrac{1-F(t)}{1-F(\theta)}\right)^{n-1}\right] dt$$

We divide all the suppliers into two sets I_1, I_2 satisfying the conditions the set I_1 contains $d-1$ suppliers, another contains $n-d+1$. The event that the set I_2 contains another $j (j = 0, 1, \cdots, d-1)$ winners is denoted as I_2^j; the supplier i's optimal price bidding strategy in the event I_2^j is recorded as $p^*(\theta_i)$; $P(I_2^j)$ indicates the probability of I_2^j.

Based on the above, the supplier i's optimal price bidding strategy in the event I_2^j is

$$p_j^*(\theta_i) = c\left(\theta_i, q_1^*(\theta_i), \cdots, q_m^*(\theta_i)\right) + \int_{\theta_i}^{\overline{\theta}} c'\left(t, q_1^*(t), \cdots, q_m^*(t)\right)\left[\left(\tfrac{1-F(t)}{1-F(\theta)}\right)^{n-d-j}\right] dt$$

and

$$P\left(I_2^j\right) = \frac{\binom{d-1}{j}\binom{n-d+1}{n-d-j+1}}{\binom{n}{n-d+1}}.$$

The supplier i is risk-neutral, so his objective is maximizing his expected utility, and the optimal price bidding strategy is

$$p^*(\theta_i) = \sum_{j=0}^{d-1} P\left(I_2^j\right) p_j^*(\theta_i).$$

It's easy to prove that $p^*(\theta_i) > p^{**}(\theta_i)$. The supplier i will maximize his utility, if he submits the subject according to (1) and (2).

4 Conclusion

We can draw that, comparing the model (*M*) with the first scoring procurement model, the supplier' optimal quality strategies is constant, but the optimal price strategy is closely related to the number of the successful bidders, the more the number is, the higher the price will be. This is consistent with that, in microeconomics, when the other conditions remain unchanged, the equilibrium price changes in the same direction as the demands [15].

This paper analysis the suppliers' optimal bidding strategies in the procurement process from a theoretical point, which has important reference value to the design of the procurement auction mechanism and the bidding strategies of suppliers. We will have specific in-depth study on how the auction mechanism influences the bidding behavior of suppliers in the following work. Only this problem is resolved, will the procurement auction theory be more practical.

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Research on DEA Model with Undesirable Factors and Shared Factors

Cheng-chao Qiu

Abstract In this paper, a new DEA model is presented to solve the problems with undesirable factors and shared factors by linear transformation with parameters based on currently undesirable factors DEA model. Compared to the DEA model with undesirable factors, the new model by this transformation retains the classification invariance.

Keywords DEA • Efficiency of industrial structure • Shared factors • Undesirable factors

1 Introduction

Industrial structure's efficiency is an important aspect of rationality of the industrial structure, to evaluate the efficiency of the industrial structure can promote industrial restructuring and accelerate economic development. When related to analysis of the efficiency, the current domestic and foreign scholars widespread use of DEA. In the standard DEA model, desirable factors are considered only. Decreases in outputs are not allowed and only inputs are allowed to decrease in the standard DEA model. However, both desirable and undesirable output and input factors may be present. If one treats the undesirable outputs as inputs, the resulting DEA model does not reflect the true production process. Lawrence M. Seiford and Joe Zhu develop a DEA model based on undesirable factors to resolve the situation with undesirable factors. Their approach can reflect the real production processing. In some cases, there may be some unknown but important factors. Consider a city's industrial structure, when we want to evaluate its efficiency, energy is a very

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important indicator, but may only overall energy consumption of the city be counted and unknown the specific energy inputs of each industrial. It can't be solved in the existing DEA model.

Based on this case consideration, the current paper develop a new DEA model to solve the situation with undesirable and share factors by making a linear transformation with variables based on Seiford and Zhu's model. The Analysis includes its advancement and rationality, where the main concern is its rationality. Therefore, using scientific methods to analyze the relative efficiency of industrial structure and to provide foundation of scientific decision for the administration will help to adjust its industrial structure, construction and accelerate the economic development.

2 Literature Review

Recently, data envelopment analysis (DEA) has been introduced to make an analysis. DEA method was firstly proposed by Charnes and Cooper [1] in 1978. A C2R model based on DEA was presented by them, which can effectively evaluate multi-input and multi-output production departments scale efficiency and technical efficiency. Combining to the model, many researchers made further demonstration and put forwards many new DEA models, such as C^2GS^2 and C^2W [2]. Furthermore, Färe advanced a new DEA method to model production system that can reduce the undesirable outputs accompanying with increasing desirable outputs [3]. Seiford and Zhu [4] brought forwards a modified DEA, where a fixed vector was introduced to transform undesirable outputs linearly, thus the problems with both desirable and undesirable outputs (or inputs) can be resolved. Lozano [5] also proposed a three-period method to problem with varied kinds outputs, where the case that only undesirable outputs and desirable inputs were contained in outputs and inputs respectively was taken into account.

In the framework of DEA theory, shared flow has been used to study phenomena such as efficiency measurement and resource allocation. The basic idea in shared flow is to measure different efficiencies of a DMU simultaneously [6], such as teaching and research, where the inputs and outputs were shared among different processes and may not be easily distinguished when measuring various efficiencies. Several methods had been proposed for better use of shared flow model, such as weighted restrictions [6], various returns to scale [7, 8], different weights on shared inputs [9], additive objective function [10], overlapping outputs [11] and panel data and non-discretionary inputs [12, 13], etc.

Until to now, there have many DEA based methods. They can be categorized into two kinds. One is undesirable factors considered model, which can also be classify to unilateral based undesirable factors DEA model and bilateral based undesirable factors combined model. And the other is both undesirable factors and factors shared model. In the following, those models mentioned above will be described in details.

3 Using the Template Both Undesirable Factors and Shared Factors DEA Model

Supposed that an economic system includes three decision make units where each is composed of three decision sub units with two kinds of inputs and outputs contained in each sub unit. Moreover, no undesirable inputs are involved in inputs and the outputs are undesirable as well as shared outputs. Shown in Fig. 1 is its basic model.

In the following, some signs are used to distinguish decision make units, decision sub units and undesirable outputs.

J and L are the indexes of decision unit and decision sub units. X and Y denote the desirable inputs and desirable outputs, respectively. B means undesirable outputs.

At same time, x_{ij}^l, A_{ij}^l, y_{rj}^l and B_{rj}^l are employed to represent the i desirable inputs, the i undesirable inputs, the r desirable outputs and the r undesirable outputs in the l decision sub unit contained in the j decision unit, respectively.

Thus in the model shown in Fig. 1, $\mathrm{B_j} = \mathrm{B}_j^1 + \mathrm{B}_j^2 + \mathrm{B}_j^3$, where $\mathrm{B_j}$ which is known denotes the given total undesirable outputs of the j decision unit and B_j^l ($l = 1,2,3$) is unknown.

Definition Suppose h_j^* ($h_j^* \geq 1$) is the optimal efficiency in the j decision unit, then the j decision unit is effective if and only $h_j^* = 1$.

It can be found from Fig. 1 that $SDMU_j^l$ is a subset of DMU_j,as far as DEA is concerned, if DMU_j is effective, thus $SDMU_j^l$ must be effective. The reason lies in that the efficiency evaluation index of decision unit is not less than 1. Sometimes, in order to reflect the relative efficiency of each decision sub unit and locate specific improving object, it is required to evaluate the efficiency of each decision sub unit. Thus a parallel network DEA model can be proposed. In this model, given that δ^l is

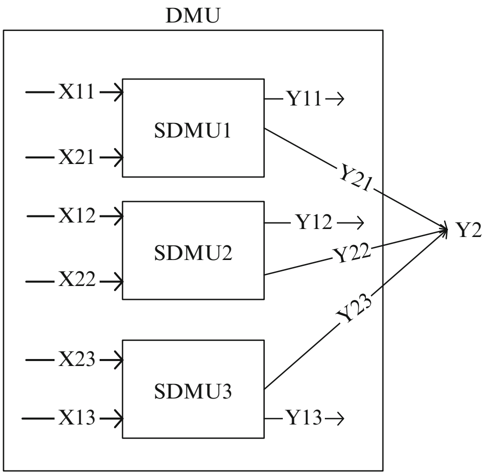

Fig. 1 Decision make units structure

the ratio of the undesirable outputs of three decision sub sets to the total undesirable outputs, meanwhile the outputs and the inputs weights are u^l and v^l, respectively, so the efficiency evaluation index of DMU_j can be computed as follows:

$$h_j = \frac{1}{3}\sum_{l=1}^{3}\frac{\sum_{r}^{2} u_r^l \overline{y}_{rj}^l}{\sum_{i=1}^{2} v_i^l x_{ij}^l} \tag{1}$$

Where $\overline{\mathrm{y}}_j^l = \left(y_j^l, \overline{B}_j^l\right)$, $\overline{B}_j^l = \omega - \mathrm{B}_j^l > 0$, $\mathrm{B}_j^l = \delta^l B_j$

We aim to obtain the optimal allocation rate, with which we can make an analysis on the efficiency among undesirable outputs of three decision sub units with the best industrial structure efficiency.

3.1 No Processing to the Inputs and the Outputs

When confronted with the inputs and the outputs without processing, we can construct an optimized model directly using Eq. 1.

$$\begin{aligned} & Max\ h_0 = \frac{1}{3}\sum_{l=1}^{3}\frac{\sum_{r=1}^{2} u_r^l \overline{y}_{r0}^l}{\sum_{i=1}^{2} v_i^l x_{i0}^l} \\ & s.t. \begin{cases} \dfrac{\sum_{r=1}^{2} u_r^l \overline{y}_{rj}^l}{\sum_{i=1}^{2} v_i^l x_{ij}^l} \leq 1, \quad j = 1, 2, \cdots, n; \quad l = 1, 2, 3 \\ u^l \geq 0, v^l \geq 0, \quad l = 1, 2, 3 \end{cases} \end{aligned} \tag{2}$$

Where n is the number of decision make units. Suppose that

$$t^l = \frac{1}{\sum_{i=1}^{2} v_i^l x_{i0}^l}, t^l u_r^l = \theta_r^l, t^l v_i^l = \pi_i^l$$

Thus Eq. 2 can be rewritten to

$$\max h_0 = \frac{1}{3}\sum_{l=1}^{3}\sum_{r=1}^{2}\theta_r^l \overline{y}_{r0}^l$$

$$s.t.\begin{cases}\sum_{i=1}^{2}\pi_i^l x_{ij}^l - \sum_{r=1}^{2}\theta_r^l \overline{y}_{rj}^l \geq 0, l = 1,2,3; j = 1,2,\cdots,n \\ \sum_{i=1}^{2}\pi_i^l x_{i0}^l = 1, l = 1,2,3 \\ \pi^l \geq 0, l = 1,2,3 \\ \theta^l \geq 0, l = 1,2,3\end{cases} \tag{3}$$

Under constrain of $\delta^1 + \delta^2 + \delta^3 = 1$, Eq. 2 can be changed into Eq. 3, where $\overline{B}_j^l = \omega - \delta^l B_j$

$$\delta^1 + \delta^2 + \delta^3 = 1 \tag{4}$$

3.2 ω as Fixed Outputs

If the undesirable outputs of all three decision sub units is B_j, the new outputs is

$$\overline{y}_j^l = \left(y_j^l, \omega, B_j\right) \tag{5}$$

If weights are set to all kinds of outputs respectively and inputs weights are set just as the above, then an optimized model can be constructed below.

$$\max h_0 = \frac{1}{3}\sum_{l=1}^{3}\frac{\sum_{r=1}^{3}\overline{u}_r^l \overline{y}_{r0}^l}{\sum_{i=1}^{2}v_i^l x_{i0}^l}$$

$$s.t.\begin{cases}\frac{\sum_{r=1}^{3}\overline{u}_r^l \overline{y}_{rj}^l}{\sum_{i=1}^{2}v_i^l x_{ij}^l} \leq 1, l = 1,2,3; j = 1,2,\cdots,n \\ v^l \geq 0, \overline{u}_1^l \geq 0, \overline{u}_2^l \geq 0, \overline{u}_3^l \leq 0, \quad l = 1,2,3\end{cases} \tag{6}$$

Suppose

$$t^l = \frac{1}{\sum_{i=1}^{2} v_i^l x_{i0}^l}, t^l u_1^l = \mu_1^l, t^l u_2^l = \mu_2^l, t^l u_3^l = \mu_3^l, t^l v_i^l = \pi_i^l, \overline{\mu}^l = \left(\mu_1^l, \mu_2^l, -\delta^l \mu_3^l\right),$$

Then it can be changed into the following linear programming problem.

$$Max\ h_0 = \frac{1}{3}\sum_{l=1}^{3}\sum_{r=1}^{3}\overline{\mu}_r^l \overline{y}_{r0}^l$$

$$s.t. \begin{cases} \sum_{i=1}^{2} \pi_i^l x_{ij}^l - \sum_{r=1}^{3} \overline{\mu}_r^l \overline{y}_{rj}^l \geq 0, \ \ l = 1, 2, 3; \ \ j = 1, 2, \cdots, n \\ \sum_{i=1}^{2} \pi_i^l x_{i0}^l = 1, \ \ l = 1, 2, 3 \\ \sum_{l=1}^{2} \delta^l = 1, \ \ l = 1, 2, 3 \\ \delta_i^l \geq 0, \ \ l = 1, 2, 3; \ \ i = 1, 2 \\ \pi^l \geq 0, \ \ l = 1, 2, 3 \\ \mu_r^l \geq 0, \ \ l = 1, 2, 3; \ \ r = 1, 2, 3 \end{cases} \tag{7}$$

The main difference between model (7) and model (3) lies in that the former transforms data inside and so does the latter outside. For data transformation outside, the optimized solution can be obtained by substituting the data transformed outside into model (3), thus the weights of transformation vector ω and undesirable outputs B_j^l are the same, which results in allocation rate δ^l either 0 or 1. However, for data transformation inside, weights of transformation vector ω and the total undesirable outputs B_j^l are varied, under such circumstance, allocation rate δ^l locates in [0 1]. In addition, model (7) and model (3) have identical efficiency, which indicates unchanged property of classification.

4 Conclusion

Based on undesirable factors DEA model, this paper study a novel DEA model to settle the case with undesirable factors and shared factors by a linear transformation involved in a few parameters, which retains classification invariance in undesirable factors based DEA model.

Based on this case consideration, the current paper develop a new DEA model to solve the situation with undesirable and share factors by making a linear transformation with variables based on Seiford and Zhu's model. This transformation retains the classification invariant of the DEA model which based on undesirable factors. In the model of Seiford and Zhu, classification invariance under data transformation is considered. The linearity and convexity of DEA are preserved after data transformation through their proposal. The model be developed in this paper satisfy the classification invariant compared with Zhu's. Therefore, the proposal compared with the original DEA model is also classification invariant.

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Study on the Determinants of Financing Structure: Based on the Differences of Ultimate Controlling Rights

Kun Su, Gui-gui Su, and Ji-lin Wang

Abstract Although there are many studies of financing structure, there was no unanimous result that it's affected by which factors. Most domestic studies ignored an important factor—corporate controlling rights, and often mixed the state-owned and non- state-owned companies. Based on the difference of ultimate controlling rights, the sample of 822 companies listed in Shanghai and Shenzhen Stock Exchanges is divided into state-owned, non-state-owned groups, as well as the overall sample. From the basic characteristics of company, equity characteristics and manager characteristics, we studied the determinants of financing structure in China. The results show that all the factors above affect financing structure at different extents, and there are significant differences on determinant factors of financing structure among different groups, especially between state-owned and non-state-owned samples.

Keywords Financing structure • Non-state-owned • State-owned • Ultimate controlling rights

1 Introduction

Financing structure means the structure ratio of capital that a company collects. While, there are many differences between state-owned and non-state-owned companies in the forming mechanism, listing conditions, the share liquidity and stock price determinants. Therefore, differentiating different ultimate controlling

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rights, and comprehensively study from the basic characteristics of company, the equity characteristics and manager characteristics has an important meaning for the research on financing structure

Foreign research on financing structure dates from 1950s. Modigliani and Miller [1] conclude that in perfect capital market, the choice of financing structure has nothing to do with company's market value, which was taken as the foundation of modern financing theory. While, because of the rigorous assumptions, later researchers gradually release the assumptions, and then studied the affecting factors of financing structure by using trade-off theory, agency theory and information asymmetry theory. Titman and Wessels [2] found that company's volatility, size and profitability significantly affect financing structure. Ozkan [3] found profitability, liquidity and growth, non-debt tax shields exert a negative effect on the borrowing ratio.

Domestic research on financing structure started from 1990s. Lu and Xin [4] found only profitability has significantly negative effect on capital structure, while company size, collateral value of assets and growth has no effects. Hong and Shen [5] showed that firm size and profitability have positive effects on debt. Chen and Zhang [6] found that firm debt ratio was positively related to size and growth, negatively related to profitability, assets liquidity, assets operating ability and risk. Huang [7] showed that profitability were negatively related to debt ratio, while size, competitive ability, size expanding were positively related to debt. Hu and Huang [8] showed that collateral value of assets was positively related to asset-liability ratio and long term debt ratio, growth, size and asset-liability ratio, long term debt ratio and bank loan ratio were significantly positively related, while profitability had significantly negative effect on asset-liability ratio and bank loan ratio.

It could be seen that there are lots of similar researches, but no unanimous results about which factors would affect financing structure [9]. What's more, most of domestic researches neglect an important factor—the company's controlling rights and always mixed state-owned and non-state-owned companies. Based on the former researches, we did research from the perspective of ultimate controlling rights and tried to analyze the listed firms' financing structure and factors which affect them in China from the following several aspects: company basic characteristics, equity characteristics and manager characteristics.

2 Theory and Hypotheses

La Porta et al. [10] proposed the research on ultimate controlling rights firstly. By tracking the controlling chain, they found that companies in most countries have ultimate controllers, including China [11]. While in China, stock equity mainly contains state-owned shares, legal-person shares and free float shares. Taking legal-person as a independent share holder has its major disadvantage: being unable to clearly identify the property of legal-person ownership. As an entity that has legal-person position, whether its share holders belong to state-owned or non-state-owned is unknown. If we continue to track the ownership upward we would find that all the legal persons are ultimately controlled by either state or private entity. Since it is the state or private entity that controls the legal person, legal-person shares actually have the property either belongs state or private person.

In order to rectify the disadvantage of current classification in stock equity, according to the ultimate property theory, the listed companies in China could be reclassified by the ultimate state-owned and non-state-owned. The property right of state-owned company is a kind of public property right, with high negotiation and monitoring cost and its long agency chain is easy to cause a series of problems such as the ownership-default, the inner control and the unhealthy development of board as well as board of supervisors; on the other side, due to its unique relationship with the government, it gets more interventions from government and has more constrains on independent decision making. Comparatively, the non-state-owned companies' property right is a kind of private property right, with clear property owner, higher agency efficiency. Then it is obviously that different ultimate control identity has different values and different objects to pursue, which could enable companies to make the best financing decisions for themselves through their controlling ability. More and more researches shown that ultimate property rights theory has more persuasive power in explaining company's behaviors.

The above two kinds of listed companies have great differences in the forming mechanism, listing forms, and stock price determinants. And each of them has its own way in operating and financing. The above financing structure theory has different effect on the two kinds of companies. This systematic differences would definitely lead to difference in their financing structure and its affecting factors. The following hypothesis is proposed:

H1: the state-owned and non-state-owned companies' financing structure has significant difference.

The larger the company size, the less possibility of expected bankruptcy, and the higher bearable debt ratio; under China's unique background, larger companies usually find it easier to get the government's support and easier to get the bank loan, as the research did by Titman and Wessels [2] and Hu et al. [8].

H2: company size is positively related to debt ratio and bank loan level.

When a company chooses its financing resource, there exists a certain order, the pecking order theory: it will prefer to inner financing firstly, then the debt financing and the equity financing finally. Firms with better profitability always have enough retained earnings, and do not need extra debt. The profitability is negatively related to assets-liabilities ratio. Domestically empirical researches also support this finding, like Lu and Xin [4], Chen and Zhang [6], Hu and Huang [8], Eriotis [12].

H3: company profitability is negatively related to debt ratio and bank loan level.

Companies with many growth opportunities always have large capital demand, which can be hardly satisfied by its own retained earnings. Because this kind of companies normally have a bright future, the old shareholders always ask help from debt in order not to decentralize their controlling power or dilute the per-share earnings. Therefore, companies with high growth opportunities always have high debt ratio, supported by Chen [6] and Hu et al. [8]; While on the other hand, this kind of companies also have higher operating risk, and the banks always ask for higher interest as the compensation which lead to a serious of conservative loans. Then we can conjecture that companies with higher growth opportunities would have lower bank loan ratio, like Titman and Wessels [2], Ozkan [3].

H4: growth opportunity is positively related to firm's total debt and negatively related to bank loan ratio.

Different assets have different collateral ability. With larger collateral assets, company's credit is higher, the risk of debt financing is lower and banks prefer to offer loans to this kind of companies, making company more able to get debt funds, like Huang [7].

H5: collateral assets are positively related to debt and bank loan.

Because the interest expense could be deducted before the tax, the debt has certain tax shield effect. The debt's tax shield effect lowers capital cost. The higher the real income tax rate, the more prefers to debt financing for the company. Then the following hypothesis is proposed:

H6: the company's real tax rate is positively related to debt level and bank loan.

The listed companies in our country always have a special dominant shareholder, and the share is dominated by non free-float shares. Then the equity's liquidity could be effectively regulated to substitute debt as a constraint on manager's opportunism, making the liquidity beneficial to reduce company debt; the higher level of liquidity, generally speaking, the better governance effect and the banks are more willing to offer loans. The equity liquidity is positively related to bank loan.

H7: company's equity liquidity is negatively related to debt level and positively related to bank loan.

On one hand, controlling shareholders have the motivation to monitor and control managers [13], and debt financing could be used as the tool to control manager's opportunism, which makes the controlling shareholders have the stimulation to use debt to constrain the manager. The equity concentration should be positively related to debt. On the other hand, the appearance of controlling shareholders and debt could be seen as the reciprocal substitute of constraint mechanism. The appearance of controlling shareholders reduces the extent of using debt to constrain managers; especially in China, most firms do not or seldom distribute dividends, the controlling shareholders are willing to use equity financing which has lower cost and no repaying pressure. From this perspective, equity's concentration ratio should be negatively related to debt and bank loan.

H8: equity concentration is negatively related to debt and bank loan.

Different financing structure means different risks, and the vested interest of top managers determines the attitude to risks, which affects financing structure. Fried and Lang [14] showed that the share ratio of managers was negatively related to debt. The more equity owned by the managers, the more tendency and ability to adjust the debt ratio downward for their own benefit. The more invested interest the top managers have, the more they would like to take conservative financing structure. This paper uses the managers' salary and equity ratio to measure the invested interest; and uses the duality of CEO and director of the board to measure the monitoring ability of board or the decision ability of managers. Jensen [15] considered that when CEO was also the director of board, the board of directors could not effectively fulfill its key monitoring function, which leads to the failure of inner control system. When CEO and director of the board is the same, the CEO has the responsibility to make decision as well as invigilate it and more control power over the board, affecting its independency. And this decision's effect on financing structure depends on their decision preference: when the CEO was appointed by controlling shareholders, there would be more preference for controlling shareholders' decision making, otherwise more preference for the individual decision making by CEO.

H9: the top managers' salary is negatively related to the company's debt ratio and bank loan level.
H10: the top manager's equity ratio is negatively related to the company's debt ratio and bank loan level.
H11: the duality of the CEO and director of board has effect on company's debt and bank loan, the direction depends on their decision making preference.

Macro-economic factors are also important aspects that the companies have to consider when financing.

H12: outside macro-economic environment has influence on the company's debt ratio and bank loan level.

Variables in the paper are summarized in Table 1.

3 Empirical Research

3.1 Sample and Data

Take companies listed in Shanghai and Shenzhen Stock Exchange Market during 2009–2011 as the original sample. We select sample by deleting the following samples: (1) new listed companies. (2) ST, PT companies. (3) companies in finance industry. (4) extreme value companies. (5) companies whose ultimate controlling right changed during 2009–2011. Finally we have 822 listed companies' panel data, 582 state-owned and 240 non-state owned companies.

Table 1 Variable definition

Variables	Abbreviation	Definition
Assets-liability Ratio	DA	Total Debt at End of the Year/Total Asset at End of the Year
Bank Loan Ratio	LD	(Short loan + Long loan)/Total debt
Company Size	SIZE	ln [(Asset at Beginning of the Year + Asset at the End of the Year)/2]
Company Profitability	PROFIT	EBIT/Total Assets
Growth Opportunities	GROWTH	Percentage Change in Sales Growth
Collateral Assets Ratio	CVA	(Inventory + Fixed Assets)/Total Assets
Act Earning Tax Ratio	AETR	the real income tax/Earnings before tax
Liquidity of Share	IS	Free float shares/Total shares
Equity Concentration	HERFIN	Square of the ten shareholders' equity
Top Managers Salary	MR	ln (the first three top managers' salary)
Top Manager's Equity	MSO	Top managers' shares/Total Shares
Duality of CEO and Director of the Board	DUAL	If the CEO is the director, Value is 1; Otherwise, 0.
Control Variable1	$YEAR_{2010}$	If belongs to 2010, Value is 1; Otherwise, 0
Control Variable2	$YEAR_{2011}$	If belongs to 2011, Value is 1; Otherwise, 0

3.2 Statistical Description and Test for Mean Value

From Table 2, we can see there are great differences between the two kinds companies' assets-liabilities ratio and bank loan. The average on assets-liabilities ratio for state-owned companies is 50.17 %, the average bank loan ratio is 43.18 %, while the values for non-state-owned companies are 52.53 and 46.54 % separately. The hypothesis 1 is supported.

What's more, from the affecting factors of financing structure we can see that except the growth and real income taxation rate, all the other factors are significantly different between the two kinds of companies.

3.3 Multiple Regression Analysis

Multiple regression results for state-owned, non-state-owned and all the samples are shown in Tables 3 and 4.

From Tables 3 and 4 it can be seen that company size is positively related to assets-liabilities ratio and the bank loan ratio, which support hypothesis 2. Growth opportunities are significantly positively related to assets-liabilities ratio in state-owned sample, while this does not pass the significant test for non-state-owned and the total samples. The result means that in non-state-owned companies, high growth could not significantly increase debt financing. Growth opportunity is negatively related to bank loan. Except for the effect on non-state-owned sample's debt ratio,

Table 2 Descriptive statistics and mean value T-test

Variable	Kinds	Min	Max	Mean	T-test
DA	State	0.0330	0.9986	0.5017	−0.0236***
	Non-state	0.0684	0.9938	0.5253	(−2.9806)
LD	State	0.0000	0.9685	0.4318	−0.0336***
	Non-state	0.0000	0.9235	0.4654	(−3.3822)
SIZE	State	18.6228	24.6454	21.3805	0.4976***
	Non-state	17.5168	23.2467	20.8829	(13.6297)
GROWTH	State	−0.9505	45.5176	0.2741	−0.7375
	Non-state	−1.0000	400.6771	1.0116	(−1.2902)
PROFIT	State	−0.4642	0.4034	0.0458	0.0111***
	Non-state	−0.5152	0.5379	0.0348	(3.4077)
CVA	State	0.0444	0.9564	0.4997	0.0426***
	Non-state	0.0432	0.9038	0.4571	(5.6278)
AETR	State	−17.8150	3.6211	0.1890	0.0091
	Non-state	−4.1219	4.2572	0.1799	(0.4169)
IS	State	0.1503	1.0000	0.4304	−0.0185***
	Non-state	0.1092	1.0000	0.4489	(−3.2536)
HERFIN	State	0.0118	0.7200	0.2356	0.0826***
	Non-state	0.0056	0.6651	0.1530	(16.8847)
MR	State	10.1999	15.9172	13.0616	0.1023***
	Non-state	9.7981	15.4489	12.9593	(2.9416)
MSO	State	0.0000	0.0122	0.0001	−0.000045**
	Non-state	0.0000	0.0082	0.0001	(−2.0447)
DUAL	State	0.0000	1.0000	0.1008	−0.0506***
	Non-state	0.0000	1.0000	0.1514	(−3.3311)

Notes: The values in () are t-statistic. The values upon () are the difference of the two samples' mean value and significance of t-test. *,**, *** indicate the significance at 10 %, 5 % and 1 %, respectively

the results support hypothesis 4. Profitability is negatively related to assets-liabilities ratio, which means that the company financing are consistent with the pecking order theory. Profitability is negatively related to state-owned company's bank loan ratio, while in non-state-owned companies this relation isn't exist, which basically support hypothesis 3. Collateral assets value is positively related to assets-liabilities ratio, positively related to bank loan ratio of state-owned companies, but fails in non-state-owned companies. The results mean that collateral assets value of non-state-owned companies has none significant effect on bank loan, which almost supported hypothesis 5.

Real income tax rate has no significant effect on either assets-liability ratio or bank loan for both kinds of companies, which left hypothesis 6 unsupported. While the listed companies doing debt financing, they seldom consider the tax shield effect of debt. Equity liquidity has no significant effect on assets-liabilities ratio, bank loan for state-owned companies, while negatively related to assets-liabilities ratio and positively related to bank loan in non-state-owned companies. Hypothesis 7 gets supported only by non-state-owned sample. This result presents that in

Table 3 Determinant of asset liability ratio

	DA		
Variable	State-control	Non-state-control	Total
	B	B	B
Constant	−0.462***	−0.436**	−0.320***
	(−4.317)	(−2.376)	(−3.538)
SIZE	0.049***	0.054***	0.046***
	(9.759)	(5.842)	(10.526)
GROWTH	***0.014****	***0.000***	***0.001***
	(***5.055***)	(***0.300***)	(***1.416***)
PROFIT	−0.798***	−0.636***	−0.722***
	(13.068)	(−7.765)	(−14.745)
CVA	0.100***	0.176***	0.119***
	(4.064)	(4.766)	(5.753)
AETR	−0.001	0.021	0.003
	(−0.093)	(1.081)	(0.381)
IS	***−0.008***	***−0.203****	***−0.079****
	(***−0.193***)	(***−3.256***)	(***−2.304***)
HERFIN	−0.166***	−0.259***	−0.233***
	(−4.262)	(−3.331)	(−6.868)
MR	−0.006	−0.008	−0.009*
	(−1.035)	(−0.882)	(−1.834)
MSO	6.775	−6.073	2.852
	(0.608)	(−0.529)	(0.357)
DUAL	***0.026****	***−0.035****	***0.008***
	(***2.017***)	(***−1.951***)	(***0.806***)
YEAR2010	0.010	0.007	0.009
	(1.052)	(0.469)	(1.085)
YEAR2011	0.019*	0.028*	0.020**
	(1.899)	(1.749)	(2.279)
Adjust R^2	0.160	0.153	0.144
F Value	28.464***	11.712***	35.136***

Notes: The number in () represents t value; *,** and *** indicate the significance at 10 %, 5 % and 1 %, respectively. The items which are italic and overstriking are different between the two kinds of samples

state-owned companies, equity liquidity has limited effect on companies' regulation, and the result is different from what we analyzed above. Equity concentration is negatively related to assets-liabilities ratio, which support our conjecture. The equity concentration ratio is negatively related to bank loan in state-owned companies, while the significant test is failed in non-state-owned companies. This indicates that because of the special relationship between state and the bank, state-owned shareholders have great power over bank loan financing.

The top managers' salary and stock ratio do not have significant effects on assets-liabilities ratio. But the salary has significantly negative effect on bank loan. Hypothesis 9's conjecture of the bank loan was supported, while its conjecture

Table 4 Determinants of bank loan ratio

	LD		
Variable	State-control	Non-state-control	Total
Variable	B	B	B
Constant	0.494***	−0.492**	0.340***
	(3.312)	(−2.127)	(2.778)
SIZE	0.015**	0.066***	0.024***
	(2.088)	(5.694)	(4.085)
GROWTH	−0.008**	−0.001*	−0.001*
	(−2.121)	(−1.920)	(−1.909)
PROFIT	***−0.325****	***−0.017***	***−0.215****
	(***−3.809***)	(***−0.169***)	(***−3.243***)
CVA	***0.227****	***0.060***	***0.164****
	(***6.601***)	(***1.292***)	(***5.876***)
AETR	0.004	0.017	0.007
	(0.426)	(0.686)	(0.776)
IS	***0.034***	***0.165****	***0.079****
	(***0.593***)	(***2.100***)	(***1.706***)
HERFIN	***−0.183****	***0.044***	***−0.177****
	(***−3.364***)	(***0.449***)	(***−3.854***)
MR	−0.032***	−0.039***	−0.035***
	(−4.163)	(−3.469)	(−5.518)
MSO	***−3.837***	***−24.107****	***−7.018***
	(***−0.247***)	(***−1.666***)	(***−0.649***)
DUAL	−0.002	−0.010	−0.001
	(−0.133)	(−0.454)	(−0.038)
YEAR2010	−0.030**	−0.028	−0.030***
	(−2.227)	(−1.402)	(−2.679)
YEAR2011	−0.050***	−0.057***	−0.054***
	(−3.490)	(−2.788)	(−4.584)
Adjust R^2	0.062	0.075	0.052
F Value	10.494***	5.79***	12.181***

Notes: The number in () represents t value; *,** and *** indicate the significance at 10 %, 5 % and 1 %, respectively. The items which are italic and overstriking are different between the two kinds of samples

about debt ratio was not supported. The reason may be that the bank loan is always a hard constraint. Compared with the assets-liabilities ratio, the bank loan could be better reflect the risk attitude of a company's top management, which shows that the top management does have the tendency to avoid risk in order to assure their invested interest. The equity ratio of top management has no significant relationship with bank loan ratio for state-owned companies, while in non-state-owned companies the relationship of the two is significant. This is mainly because that ratio is always much higher in non-state-owned companies than in state-owned companies. Hypothesis 10 gets supported only by non-state-owned sample. The duality of CEO and director of board could increase debt level of state-owned companies significantly, while reduce that in non-state-owned companies and have no significant effect for the whole sample. This results indicate that due to the ownership-default problem for state-owned companies, if CEO and the director of board were the same, the owner's supervision over manager becomes even limited, and the manager tends to choose high debt ratio. While in non-state-owned companies, if CEO and director of the board was the same, the director usually was assigned by controlling shareholder. The duality could better express the willingness of the owner, who tends to choose low debt level in case of bankruptcy. There is no significant effect for the duality on bank loan ratio. For hypothesis 11, only the part of debt level was supported. From the significance level of the index $YEAR_{2010}$ and $YEAR_{2011}$, it could be seen that macro-economic policy does have certain effect on financing structure, which supported hypothesis 12.

Above all, we can conclude that the affecting factors of financing structure are quite different between state-owned companies and non-state-owned companies. There would be major differences between the separate analysis and the mixed analysis, which implies that the former domestic research method of mixing the two kinds of companies together is inappropriate.

4 Conclusions

Based on the difference of ultimate controlling rights, we find that there are significant differences between the two kinds of companies' financing structure, and then we did comparison study for the affecting factors separately and found great differences, which indicated that method of mixing them together was inappropriate.

We found that company size, profitability, collateral assets value, equity concentration and duality of CEO and director of board all have significant effects on assets-liabilities ratio for both types of companies, with the duality has an opposite effect in each type. What's more, growth has significant effect on assets-liabilities ratio in state-owned companies but no significant effect on assets-liabilities ratio in non-state-owned companies. Equity liquidity has significant effects on assets-liabilities ratio in non-state-owned companies and little effect on that in state-owned ones. Real income taxation rate, top manager compensation and top managers' equity ratio have no significant effect in the two kinds companies. Company size, growth and top management compensation have significant effects on bank loan for both kinds of companies; Profitability, collateral value of assets and equity concentration have significant effects on state-owned companies' bank loan, but failed in significant test for non-state-owned companies. Equity liquidity and top management's equity ratio have significant effects on bank loan in non-state-owned companies but no significant effect on bank loan in state-owned companies. Real income tax rate, duality of CEO and director of board do not have significant effect on bank loan for the two kinds of companies. At the same time, the macro-economic policy has certain effects on financing structure.

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Research on Benefits Distribution Model of Industry Technology Innovation Strategic Alliance Based on Investment of Resource and Risk Compensation

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Abstract Benefits distribution of industrial technology innovation strategic alliances is one of the key factors affect its stable operation. This paper first presents a benefits distribution model based on the member's investment of resources, and then introduces the risk factor to revise the model. Members who share higher risk will get more risk compensation. The purpose of the model is trying to build a more equitable mechanism of benefits distribution. On the basis of the theoretical research, the paper also gives the results of empirical analysis.

Keywords Benefits distribution • Industry technology innovation strategic alliance • Investment of resources • Risk compensation

1 Introduction

As global competition intensifies, the scale, speed and scope of technological innovation continues to expand, companies face increasingly complex technical and economic issues [1]. Single enterprise is difficult to completely rely on its own strength to grasp the uncertainty of technological innovation. This leads to the enterprises to actively seek to establish a variety of collaborative innovation mode.

Industry technology innovation strategic alliance (hereinafter referred to as 'the Alliance') is founded by enterprises, universities, research institutions or other organizations. It is a cooperative technology innovation organization which aims at meeting industry development needs and common interests of all parties, targets to enhance the technological innovation capability of industry [2]. Members of

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the Alliance usually sign a legally binding contract to obtain protection. It is characterized by joint development, complementary advantages, benefit-sharing and risk-sharing. In 2007, the Ministry of Science and Technology established the first four industrial technology innovation strategic alliances in the fields of iron and steel, coal, chemicals and agricultural equipment. Since then, the field of high-tech, rural and social development is active in promoting alliance building. According to incomplete statistics, as of 2011, more than one hundred alliances were established in some provinces and municipalities, such as Beijing, Liaoning, Jiangsu, Zhejiang, Hubei, Guangdong, Hebei, Gansu and Qinghai, etc. These alliances were built on the basis of local competitive industries and pillar industries.

With industry technology innovation strategic alliance building boom, this area is also increasingly become the focus of the scholars' attention. Industry technology innovation strategic alliance formed with the aim that members expect to obtain higher returns (such as more results, technology level improvement, knowledge acquisition and profits increased, etc.) through collaborative research than a separate study. Industrial technology innovation alliance members are trying to achieve 'win-win' results from the cooperation, establish a mechanism of common inputs and benefits-sharing, and build a community of interests. At the same time, running of the Alliance also bears the risk, including the risks of failure of technology development as well as participants in opportunistic behavior [3–6]. Therefore, whether the mechanism of benefits distribution and risk compensation is reasonable or not, is the key factor which will affect the members' cooperative enthusiasm, the Alliance's stability, the running state and development prospects of the Alliance.

Ji Yihua et al. (1999) are the earliest scholars of the country to conduct a comprehensive study of the mode of cooperative technological innovation benefits distribution. They proposed a benefits distribution mode in three ways, including total pay, commission payment and mixed payment [7]. Guo Fenglan (2004) made a mathematical analysis of benefits allocation of Industry-University-Research institute (IUR) collaboration by using game theory, and established an optimized mathematical model of benefits distribution [8]. Luo Li and Lu Ruoyu (2000) use the game theory to build a cooperative countermeasure model. They recommended the distribution of benefits of the sales commission, and gave the quantitative ratio of commission [9]. Sun Dongchuan (2001) and Guiping (2003) applied Nash bargaining model in benefits distribution of the Alliance and considered that it must ensure 'sum of each allocated is exactly equal to the total maximum income of the Alliance' as well as 'income allocated from the Alliance can not be less than the revenue by member's operations alone', otherwise, the Alliance will not need to exist [10, 11]. Luo Li (2001) and Jia Ping (2003) described the Alliance's benefit distribution model with Sharply value [12, 13]. Cao Xiaohua (2010) introduced the Nash equilibrium theory to analyze the benefits distribution program of the Automotive Technology Innovation Strategic Alliance. She built a benefits distribution model of n ($n > 2$) members of the Automotive Technology Innovation Strategic Alliance, and deduced asymmetric Nash equilibrium optimal allocation programs based on the member's satisfaction [14].

This article gives a benefits distribution model based on the valuation of member's investment, and then introduces the risk factor to revise the model in order to achieve a certain compensation for the risk borne by the members of the Alliance.

2 Forms of Benefits and Distribution Principles of Industry Technology Innovation Strategic Alliance

2.1 Forms of Benefits of Industry Technology Innovation Strategic Alliance

The revenue of the industry technology innovation strategic alliance can be divided into direct benefits and indirect benefits. The direct benefits are the benefits that can be obtained directly from Alliance operation. The indirect benefits can be achieved only under the influence of some external environmental factors. Gaining direct benefits is the purpose of the establishment of industry technology innovation strategic alliance, whereas the level of indirect benefits will impact on the sustainable development of the Alliance.

The direct benefits of the Alliance can be divided into the following three forms:

1. New product. For enterprises in the Alliance, new products developed by the Alliance can be quickly turned into profits through their marketing channels. So the new product can be used as a form of direct benefits to allocate to members of the Alliance.
2. Technology patents. The main purpose of industry technology innovation strategic alliance to establish is to develop the industry key generic technologies. Therefore, a large number of patents are bound to produce in the running of the Alliance. These patents are jointly developed by alliance members, should be shared by the members of the Alliance. However, different types of alliance members will apply the technology patents in different ways. Companies can improve production efficiency through technology patents to earn high profits. Universities and research institutions usually gains through technology transfer.
3. Profits. Profits refer to the sales revenue of the Alliance's product, as well as the revenue of the Alliance's technology patents transfer. Benefits in the form of currency are easy to be distributed among the Alliance members.

The indirect benefits of the Alliance also can be divided into the following three forms:

1. Technological achievements. A series of technological achievements will be produced in the cooperation of basic research, laboratory research, pilot, national testing center inspection, competent authorities for approval and mass production of the Alliance members. These technological achievements include technical

know-how, production secrets and management experience. Although these gains are not presented in the form of currency in the Alliance account, but still the important gains of the Alliance.
2. Goodwill. The good image of the Alliance will bring goodwill and reputation to Alliance members. The members will be proud of joining the Alliance, and the goodwill of the Alliance will bring intangible benefits for its members at the same time.
3. Capacity for sustainable development. Alliance members will improve their technical and energy saving capabilities through collaboration innovation. The capacity for sustainable development will be transformed into business opportunities, and is also an important part of alliance revenue.

As indirect benefits are difficult to carry out a quantitative assessment in a short term, the benefits distribution model discussed in this article is mainly for direct income.

2.2 Benefits Distribution Principles of Industry Technology Innovation Strategic Alliance

Benefits distribution of industry technology innovation strategic alliance should be guided by the following principles:

1. Distributed in accordance with the contribution. Alliance members should be proportional to the gain and input. The more input, the greater the gain. The less investment, the less income. In considering the contribution of the Alliance members, not only to consider the capital-based resource contribution, but also consider those contributions of knowledge-based resources. The Alliance needs to conduct a comprehensive and reasonable assessment of member's investment. This is the basis of the distribution of benefits.
2. Distributed in accordance with the risk level. There are many uncertain risks during the Alliance operation. In the design of the benefits distribution model, the risks of each member should be fully considered. Higher risk members should be considered given more compensation. This will help to encourage the member to assume risk tasks actively.
3. The full participation of the members in distribution. Due to the different needs of different members, the benefit distributed completely in accordance with a certain proportion mechanically is unscientific. This will lead to lower satisfaction of alliance members. The Alliance should allow all members to participate in the process of benefits distribution to take full account of their needs.
4. Mutual benefit and common development of all members. Due to the diversity of the types of technology innovation strategic alliance revenue, it is difficult to predict all possible types of gains in advance. So the contract signed at the

beginning usually could not defined all possible forms of distribution, which may lead to conflict of interests among members. For those revenue not explicitly specified in the initial contract, the members of the Alliance should allocated them in line with the principle of mutual benefit and common development.

3 The Model of Benefits Distribution of Industry Technology Innovation Strategic Alliance

3.1 *Basic Assumptions*

In order to build the model, some assumptions and derivations are given below:

1. Revenue of completed project will be allocated, and the revenue of unfinished project will be carried forward to the next year;
2. Set there are n members in an industry technology innovation strategic alliance, $N = \{1, 2, \ldots, n\}$ is a collection of all the Alliance members;
3. Let m represents the number of completed projects in a given year of the alliance, $M = \{1, 2, \ldots, m\}$ is a collection of completed projects in the year;
4. Set that both tangible and intangible resources invested by the members of the Alliance can be valued. The tangible resources, including financial resources (funds) and material resources (land, R&D equipment, raw materials, etc.). Whereas the intangible resources, including human resources (R&D personnel, management personnel, etc.), technical resources (technology patents and technology innovative capacity), the management resources (company culture, company policies, governance structure and incentive system, etc.) and social relations resources (external collaboration capacity). Assume that the total value of resources put into project j by member i is R_{ij}, the total value of resources put into the Alliance by member i is R_i, and then the total value of resources put into project j is $R_j = \sum_{i=1}^{n} R_{ij}$, the total value of resources put into the Alliance in the given year is $R = \sum_{i=1}^{n} R_i$;
5. Let C represents the total costs of the Alliance's research and development activities in the given year, and obviously $C \leq R$. The investment of unfinished project is not included in the total cost of R&D activities in this year. It will be carried over to next year.
6. Let C_g represents the total fixed costs of the Alliance, C_j represents the total costs of project j, C_{jb} represents the variable costs of project j, C_{jg} represents the shared fixed costs of project j, and then we have that $C = C_g + \sum_{j=1}^{m} C_{jb}$, $C_j = C_{jg} + C_{jb}$;
7. Let V represents the total revenue of the Alliance, V_j represents the total revenue of project j. When we spread fixed costs in accordance with the proportion of project's benefits in total revenue, we can get the expression of C_j: $C_j = \frac{V_j}{V} C_g + C_{jb}$;

8. Let E_j represents the net profit of project j, we have $E_j = V_j - C_j$;
9. Let C_{ijg} represents the shared fixed costs of member i in project j, then we have $C_{ijg} = \frac{R_{ij}}{R_j} C_{jg}$;
10. Let C_{ijb} represents the shared variable costs of member i in project j, we know that it is equivalent to R_{ij} (the total value of resources put into project j by member i), so we have $C_{ijb} = R_{ij}$.

3.2 The Benefits Distribution Model Not Take into Account the Risk Compensation

Based on the assumptions and derivation above, we can get the expression of net profit of member i in project j below:

$$E_{ij} = E_j \frac{C_{ijg} + C_{ijb}}{C_j}. \tag{1}$$

We put the expressions of E_j, C_{ijg}, C_{ijb} and C_j which were derived in 3.1 into (1), then the benefits distribution model not take into account the risk compensation can be expressed as follow:

$$E_{ij} = \left(V_j - \frac{V_j}{V} C_g - C_{jb} \right) \frac{\frac{R_{ij} V_j}{R_j V} C_g + R_{ij}}{\frac{V_j}{V} C_g + R_j}. \tag{2}$$

3.3 The Benefits Distribution Model Consider the Risk Compensation

To compensate the risks of the members, we must first assess the level of their risks. According to the definition of risk, the level of risk is essentially a function of the probability and loss severity of adverse events. That is, the greater the probability of occurrence of the risk and the more severe the loss, the higher level of Alliance's risk.

Let P represents risk probability, L represents loss severity, the subscript f denotes the risk event occurs, the subscript s represents the risk event does not occur, then we have

$$P_f = 1 - P_s, L_f = 1 - L_s.$$

As the risk factor K_f is the likelihood estimation of the probability and loss severity of risk events [15], so there is

$$K_f = 1 - P_s L_s = 1 - \left(1 - P_f\right)\left(1 - L_f\right) = P_f + L_f - P_f L_f.$$

Let K_{ij} represents the risk factor of member i in project j, then the total risks of all Alliance members in project j is $K_j = \sum_{i=1}^{n} K_{ij}$. The shared proportions of member i in total risk of project j is $K'_{ij} = \frac{K_{ij}}{K_j}$. It is easy to draw that $\sum_{i=1}^{n} K'_{ij} = 1$. And the difference between shared proportions of member i and the average sharing of risk in project j is $\Delta K_{ij} = K'_{ij} - \frac{1}{n}$. Obviously there is $\sum_{i=1}^{n} \Delta K_{ij} = 0$.

When $\Delta K_{ij} \geq 0$, it shows that the sharing of risk of member i in project j is higher than the Alliance's average level. In this case, member i should be given positive risk compensation. When $\Delta K_{ij} < 0$, it shows that the sharing of risk of member i in project j is lower than Alliance's average level. Then member i should be given negative risk compensation. The amount of the compensation given to the members of positive risk compensation comes from the members of lower risk level than average.

According to earlier assumptions, V_j represents the total revenue of project j. Let B_{ij} represents the risk compensation value, then there is

$$B_{ij} = \Delta K_{ij} \times V_j \times \alpha. \tag{3}$$

Where α ($\alpha \leq 1$) represents risk adjustment coefficient [16]. The coefficient can adjust the amount of risk compensation. Its level is generally determined by consultation with the members.

By (2) and (3), the benefits distribution model considers the risk compensation can be given as follow:

$$\begin{aligned} E_{ij}{}^{f} &= \left(V_j - \frac{V_j}{V} C_g - C_{jb}\right) \frac{\frac{R_{ij} V_j}{R_j V} C_g + R_{ij}}{\frac{V_j}{V} C_g + R_j} + B_{ij} \\ &= \left(V_j - \frac{V_j}{V} C_g - C_{jb}\right) \frac{\frac{R_{ij} V_j}{R_j V} C_g + R_{ij}}{\frac{V_j}{V} C_g + R_j} + \Delta K_{ij} \times V_j \times \alpha. \end{aligned} \tag{4}$$

4 Empirical Analysis

Assume that one industry technology innovation strategic alliance has three members: A, B and C. The three members developed two projects jointly in 2012. The first project has finished during that time while the second project has not finished and will carry over to the next year. The total fixed costs of the Alliance in 2012 is

500 thousands yuan. The total revenue of the first project is 15 million yuan. The value of investment of resources of A, B and C are showed in Table 1. The risk borne by the member A, B and C is 4/15, 7/15 and 4/15 respectively. The risk adjustment coefficient is 0.4.

Then we can calculate the available profit of member A, B and C by (4). The results have already considered member's risk compensation:

$$
\begin{aligned}
E_{A1}{}^{f} &= \left(15,000 - \frac{15,000}{15,000} \times 500 - 6,200\right) \times \frac{\frac{1,800 \times 15,000}{6,200 \times 15,000} \times 500 + 1,800}{\frac{15,000}{15,000} \times 500 + 6,200} \\
&\quad + \left(\frac{4}{15} - \frac{1}{3}\right) \times 15,000 \times 0.4 = 8,300 \times 0.29 - 400 = 2,007
\end{aligned}
$$

$$
\begin{aligned}
E_{B1}{}^{f} &= \left(15,000 - \frac{15,000}{15,000} \times 500 - 6,200\right) \times \frac{\frac{2,400 \times 15,000}{6,200 \times 15,000} \times 500 + 2,400}{\frac{15,000}{15,000} \times 500 + 6,200} \\
&\quad + \left(\frac{7}{15} - \frac{1}{3}\right) \times 15,000 \times 0.4 = 8,300 \times 0.387 + 800 = 4,012
\end{aligned}
$$

$$
\begin{aligned}
E_{C1}{}^{f} &= \left(15,000 - \frac{15,000}{15,000} \times 500 - 6,200\right) \times \frac{\frac{2,000 \times 15,000}{6,200 \times 15,000} \times 500 + 2,000}{\frac{15,000}{15,000} \times 500 + 6,200} \\
&\quad + \left(\frac{4}{15} - \frac{1}{3}\right) \times 15,000 \times 0.4 = 8,300 \times 0.323 - 400 = 2,281
\end{aligned}
$$

As can be seen from the above calculation process, the three members firstly share the net profit of the first project (total 8,300 thousands yuan) according to their respective investments, and then get their risk compensation according to their shared proportions of the risk. Because the shared risk proportion of member B is higher than average, B will get risk compensation of 800,000 yuan. Whereas A and C are required to come up with 400,000 yuan respectively as the risk compensation of B, because the two members share the risk of below-average. The results reflect the benefits distribution principle of coexistence of gains and risk.

5 Conclusion

In this paper, a benefits distribution model of industry technology innovation strategic alliance is discussed. The model considers both investment of resources and risk compensation of the Alliance members. This distribution mode makes the Alliance members who share higher risk can get more compensation. It will help to achieve the fairness of the Alliance's benefits distribution. Through the

Table 1 The value of investment of resources in first project (currency unit: thousands Yuan)

	Total investment of resource	Investment of material resources	Investment of financial resources	Investment of human resources	Investment of technology patent	Investment of technology innovation resources	Investment of management resources	Investment of social relations resources
A	**1,800**	500	300	50	300	300	50	300
B	**2,400**	600	200	200	600	450	100	250
C	**2,000**	400	100	200	500	500	100	200
Total	**6,200**	1, 500	600	450	1, 400	1, 250	250	750

establishment of a fair benefits distribution mechanism, the Alliance will be able to motivate members to participate in cooperative technology innovation activities actively, and will help to improve the stability and performance of the Alliance.

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Study on the Evaluation of Growth Capability of High-Tech Enterprises in China's Regional Innovation System

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Abstract In the regional innovation system, high-tech enterprises integrate varieties of effective resources through technology innovation, lead and effect other enterprises technologies and economic development, and accelerate the whole system to improve. The growth capability of high-tech enterprise is the main factor to measure the comprehensive strength of regional innovation system as it has become an important indicator to show the development degree of regional innovation system. This article establishes an index system of evaluating the growth capability of high-tech enterprise, and evaluates the growth capability of high-tech enterprises in eight economic areas through osculating value evaluation method, and puts forward some countermeasures to provide policy decision for the future development of Chinese regional innovation system.

Keywords Evaluation • Growth capability • High-tech enterprise • Regional innovation system

1 Introduction

A regional innovation system, as an important part of the national innovation system, was brought up in the late 1990s and highly emphasized by the academic circle and the governments of many countries. The construction of a regional invocation system is inseparable from the formation and development of industrial clusters and different industries support the innovation system to various degrees. A perfect regional innovation system tends to appear and develop where high-tech enterprises gather earliest. In China' regional innovation system, with the market

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as the main resource allocation mode, high-tech enterprises should have a central position and serve as one of core subjects of technical innovation.

However, the actual situation is that due to the lack of understanding of high-tech enterprises in the innovation system, the conditions and foundation that influence the function effectiveness of high-tech enterprises are far from ideal. In view of this, with high-tech enterprises in the regional innovation system as the research subject of the paper, an evaluation index system for the growth capacity of high-tech enterprises is established. An osculating value evaluation method is adopted to evaluate the growing situation of high-tech enterprises in 8 comprehensive economic areas so that the high-tech enterprises in each area can bring into play their advantages, make up for their insufficiency, further improve the construction of the regional innovation system and provide ideas and reference for the prosperity and development of the regional economy.

2 Establishment of an Evaluation Model for Growth Capacity of High-Tech Enterprises in the Regional Innovation System

2.1 Basic Principle for Establishing an Evaluation Index System

It is well known that high-tech enterprises are characterized by high technology, input, profitability, risk and short life cycle and the high-tech enterprises in the regional innovation system feature a more complex operation mechanism and environment background in their development process. Therefore, the evaluation index system for the growth capacity of high-tech enterprises in the regional innovation system needs to follow the principles below [1].

2.1.1 Principle of Systematic and Scientific

The selection of indexes should be able to reflect the connotation and law of high-tech enterprises and the evaluation index system must feature integrity and systematic, so the evaluation index system for growth capacity of high-tech enterprises should be hierarchical, with contents covering the market, R&D, and finance of enterprises [2]. At the same time, as the growing situation of enterprises involve many factors, how to realize high-level abstraction and sum up and extract the most important and the most representative indexes is the key and difficulty involved in designing an index system. One-sided pursuit of comprehensiveness will result in too many indexes, causing illusion and confusions in judgment and easily lead to distortion of evaluation results [3].

2.1.2 Principle of Practicality and Operability

The data required for an evaluation index system should be easy to investigate and collect and consistent with existing accounting indexes, statistical indexes and business accounting indexes [4]. The data should be obtained from statistical data as much as possible or obtained by processing existing data. Under the guidance of the principle of practicality, the evaluation index system for growth capacity of high-tech enterprises and comprehensive evaluation methods should be able to be used for conducting scientific quantitative evaluation and ranking of growth capacity of high-tech enterprises in a number of regional innovation systems.

2.1.3 Principle of Guidance and Development

An evaluation index system for growth capacity of high-tech enterprises is established with a view to tap various resources that enterprises haven't effectively controlled and diagnose various production organization elements of enterprises to guide effective resource allocation of enterprises and promote the perfection and development of a regional innovation system. At the same time, traditional enterprise growth evaluation has the past and current situation of enterprises as the subject in most cases, while the evaluation of growth of high-tech enterprises in the regional innovation system not only involves the consideration of the past and present situation of enterprise but also pays more attention to the further of enterprises [5]. Therefore, it is necessary to comprehensively consider the survival, development and continuous innovation capacity of enterprises while designing an evaluation index system for growth capacity of high-tech enterprises.

2.2 Establishment of an Evaluation Index System

An evaluation index system for growth capacity of high-tech enterprises is established from two aspects, survival and development capacity and sustainable innovation capacity, by following the basic principles for establishing an evaluation index system for growth capacity of high-tech enterprises [6], with four dimensions (financial strength, market competitiveness, research and development strength and new product competitiveness) reflecting the growing situation (as shown in Table 1 [7]) of high-tech enterprises in the regional innovation system, with specific calculation formulas of indexes as follows:

1. Survival and development capacity indexes

   Sales revenue growth rate = (sales volume at the end of investigation − sales volume at the beginning of investigation)/sales volume at the beginning of investigation.

Table 1 Evaluation index system for growth capacity of high-tech enterprises in the regional innovation system

Level 1 index	Level 2 index	Level 3 index	Level 4 index
Growth capacity of high-tech enterprises	Survival and development capacity	Financial strength	Sales revenue growth rate Net profit growth rate
		Market competitiveness	Market share Export sales revenue proportion
	Sustainable innovation capacity	Research and development strength	Proprietary technology proportion R&D personnel proportion R&D fund proportion
		New product competitiveness	New product sales revenue proportion New product development fund proportion

Net profit growth rate = (net profit at the end of the current period − net profit at the end of the previous period)/net profit at the end of the previous period

Market share = product sales revenue/total product sales revenue in the same industry

Export sales revenue proportion = total export volume/enterprise product sales revenue

2. Sustainable innovation capacity index

Proprietary technology proportion = number of enterprise proprietary technologies/total number of proprietary technologies

R&D personnel proportion = R&D personnel/employment personnel

R&D fund proportion = R&D fund/sales revenue

New product sales revenue proportion = new product sales revenue/total sales revenue of enterprise products

New product development fund proportion = new product development fund/new product sales revenue

2.3 *Evaluation Model for Growth Capacity of High-Tech Enterprises*

Based on the evaluation index system for growth capacity of high-tech enterprise, an appropriate evaluation method is selected to conduct comprehensive evaluation in order to increase the objectivity, practicality and authenticity of evaluation through rational and accurate processing of data and maximum used an objective method. In this paper, an osculating value evaluation method which intended to look for a decision-making point closest to the strongest point and farthest from the weakest point [8]. The weight of the method is based on the information contained in the data instead of subjective weight, and the method can meet the data property requirements of indexes, without involving the issue whether indexes are relevant, featuring strong recognition capacity, simple and clear calculation process and more objective and impartial evaluation results.

The osculating value evaluation method is an optimal method in Systems Engineering. Its basic idea is to determine "the strongest point" and "the weakest point" of each evaluation index of the object to be evaluated first, then compare the distance between the object to be evaluated and "the strongest point" & "the weakest point" of each evaluation index and finally calculate the osculating value [9].

2.3.1 Establishing and Standardizing Index Matrix

Take Value a_{ij} for the program set A_i ($i = 1, 2, \ldots, m$) under the index S_j (j = 1, 2... n) and obtain the index matrix $A = \left(a_{ij}\right)_{m\times n}$. Due to numerous indexes involved in the program and complicated relationships between numerous indexes, the difference between positive indexes (the higher the index value, the stronger the capacity) and reverse indexes (the higher the index value, the weaker the capacity) and different dimension of each index, the index matrix is standardized for convenient comparison [10].

$$\begin{cases} \dfrac{a_{ij}}{\sqrt{\sum\limits_{i=1}^{m}\left(a_{ij}\right)^2}} & \text{When } j \text{ is a positive index} \quad (1) \\ \dfrac{-a_{ij}}{\sqrt{\sum\limits_{i=1}^{m}\left(a_{ij}\right)^2}} & \text{When } C_{ij} \text{ is a negative index} \quad (2) \end{cases}$$

A standardized index matrix $X = (x_{ij})_{m \times n}$ is obtained [11].

2.3.2 Determining the Strongest Point and the Weakest Point of the Program Set

Set: $x_j^+ = \max\{x_{ij}\}$,

$$x^- = \min\left\{x_{ij}\right\} \text{ (j} = 1, 2, \ldots, \text{n)} \tag{3}$$

The strong point set: $A^+ = (X_1^+, X_2^-, \ldots, X_n^+)$

The worst point set: $A^- = (X_1^-, X_2^-, \ldots, X_n^-)$

A satisfactory program is to find out a decision-making point closest to the strongest point and farthest from the weakest point in the decision-making point set [12].

2.3.3 Calculating the Osculating Value of Each Program

The osculating value of Program A_i is:

$$C_i = d_i^+/d^+ - d_i^-/d^- \tag{4}$$

Where:

$$d_i^+ = \left[\sum^n \left(x_{jj} - x_j^+\right)^2\right]^{1/2} \tag{5}$$

$$d_i^- = \left[\sum^n \left(x_{jj} - x_j^+\right)^2\right]^{1/2} \tag{6}$$

$$d^+ = \min\left(d_i^+\right), \quad d^- = \max\left(d_i^-\right) \tag{7}$$

d_i^+ and d_i^- indicate the Euclidean distance between program A_i and the optimal program A^+ and the distance between program A_i and the worst program A^- respectively. d^+ and d^- indicate the minimum value of m strongest point distances and the maximum value of m weakest point distances. The value of C_i reflects the degree to which the program set deviates from the strongest point. When $C_i > 0$, A_i deviates from the strongest point, the larger the value, the larger the deviation; when $C_i = 0$, A_i is the closest to the strongest point. With the value of C_i as the decision criterion, the program with the minimum value of C_i is a satisfactory program.

3 Evaluation and Analysis of Growth Capacity of High-tech Enterprise in China's Regional Innovation System

Eight comprehensive economic areas (as shown in Table 2) are selected as samples, with an osculating value method used to conduct comprehensive evaluation and analysis of the growth capacity of high-tech enterprises in China's regional innovation system [12]. The original data of the 8 comprehensive economic areas are as shown in Table 3, in which all indexes are positive indexes [13].

Due to different dimensions of indexes, the data in the table are standardized using formulas (1) and (2) in the model, with standardized values obtained (as shown in Table 4).

The strongest point and the weakest point can be obtained using formula (3) and the data in Table 5: $A^+ = (X_1^+, X_2^+, \ldots, X_n^+)$, $A^- = (X_1^-, X_2^-, \ldots, X_n^-)$, as shown in Table 5.

Table 2 Eight comprehensive economic areas in China

Eight comprehensive economic areas	Northeast comprehensive economic area	Liaoning, Jilin, Heilongjiang
	North coastal comprehensive economic area	Tianjin, Hubei, Shandong, Beijing
	East coastal comprehensive economic area	Jiangsu, Shanghai, Zhejiang
	South coastal comprehensive economic area	Hainan, Fujian, Guangdong
	Yangtze River middle-reach comprehensive economic area	Anhui, Jiangxi, Hubei, Hunan
	Yellow River middle-reach comprehensive economic area	Shaanxi, Shanxi, Inner Mongolia, Henan
	Large southwest comprehensive economic area	Chongqing, Sichuan, Guizhou, Yunnan, Guangxi
	Large northwest comprehensive economic area	Gansu, Qinghai, Ningxia, Sinkiang and Tibet

Table 3 Original data of eight economic areas

Index / Economic area	Sales revenue growth rate	Net profit growth rate	Market share	Export sales revenue proportion	Proprietary technology proportion	R&D personnel proportion	R&D fund proportion	New product sales revenue proportion	New product development fund proportion
Northeast comprehensive economic area	0.1869	0.3156	0.0357	0.1739	0.0291	0.0461	0.0211	0.1182	0.2131
North coastal comprehensive economic area	0.0587	0.2293	0.1697	0.3450	0.1300	0.0499	0.0160	0.3270	0.0486
East coastal comprehensive economic area	0.0395	-0.0256	0.3548	0.5991	0.2473	0.0453	0.0127	0.2040	0.0742
South coastal comprehensive economic area	0.0399	0.5031	0.3149	0.6430	0.4671	0.0501	0.0183	0.2250	0.0910
Yangtze River middle-reach comprehensive economic area	0.2924	0.2723	0.0473	0.1363	0.0515	0.0570	0.0204	0.1968	0.1329
Yellow River middle-reach comprehensive economic area	0.1745	0.1628	0.0330	0.0755	0.0326	0.0554	0.0206	0.1378	0.1713
Large southwest comprehensive economic area	0.2335	0.1713	0.0425	0.1233	0.0393	0.0569	0.0188	0.3137	0.0742
Large northwest comprehensive economic area	0.1137	0.1226	0.0021	0.0926	0.0031	0.0534	0.0231	0.2319	0.1308

Source of Data: 2010 High-tech Industry Yearbook, 2010 Science and Technology Yearbook

Based on (5) and (6), d_i^+ and d_i^- can be calculated, and the osculating value of each area can be obtained through calculation based on (4) (as shown in Table 6).

Based on the osculating value, the total score ranking for growth capability of eight comprehensive economic areas high-tech enterprises is conducted (as shown in Table 7).

Table 4 Standardized data of eight economic areas

Economic area \ Index	Sales revenue growth rate	Net profit growth rate	Market share	Export sales revenue proportion	Proprietary technology proportion	R&D personnel proportion	R&D fund proportion	New product sales revenue proportion	New product development fund proportion
Northeast comprehensive economic area	0.3941	0.4252	0.0699	0.1766	0.0529	0.3134	0.3899	0.1817	0.5883
North coastal comprehensive economic area	0.1237	0.3089	0.3326	0.3504	0.2364	0.3397	0.2951	0.5027	0.1341
East coastal comprehensive economic area	0.0832	-0.0344	0.6955	0.6084	0.4498	0.3085	0.2351	0.3137	0.2049
South coastal comprehensive economic area	0.0840	0.6778	0.6172	0.6530	0.8495	0.3410	0.3388	0.3459	0.2513
Yangtze River middle-reach comprehensive economic area	0.6165	0.3669	0.0927	0.1384	0.0937	0.3876	0.3775	0.3026	0.3669
Yellow River middle-reach comprehensive economic area	0.3679	0.2193	0.0647	0.0766	0.0593	0.3772	0.3811	0.2119	0.4730
Large southwest comprehensive economic area	0.4924	0.2307	0.0834	0.1252	0.0715	0.3875	0.3480	0.4823	0.2049
Large northwest comprehensive economic area	0.2398	0.1652	0.0041	0.0940	0.0057	0.3637	0.4266	0.3565	0.3612

Table 5 Strongest and weakest points of the evaluation system

Index	$j = 1,2,\ldots,9$	x_j^+	x_j^-
Sales revenue growth rate	1	0.6165	0.0832
Net profit growth rate	2	0.6778	−0.0344
Market share	3	0.6955	0.0041
Export sales revenue proportion	4	0.6530	0.0766
Proprietary technology proportion	5	0.8495	0.0057
R&D personnel proportion	6	0.3876	0.3085
R&D fund proportion	7	0.4266	0.2351
New product sales revenue proportion	8	0.5027	0.1817
New product development fund proportion	9	0.5883	0.1341

According to the osculating value of each economic area, the eight economic areas can be divided into three classes:

1. Excellent-class growth capacity area: with osculating value between 0 and 1, including South Coastal Comprehensive Economic Area and East Coastal Comprehensive Economic Area [14], where the overall growth level of high-tech enterprises is in the front rank, with significant advantages.
2. Fair-class growth capacity area: with osculating value between 1 and 1.5, including North Coastal Comprehensive Economic Area, Yangtze River Middle-reach Coastal Comprehensive Economic Area, Northeast Comprehensive Economic Area and Large Southwest Comprehensive Economic Area, where the growing

Table 6 Distance between the strongest point and the weakest point and obtained osculating value of each economic area

Economic area	Index d_i^+	d_i^-	C
Northeast comprehensive economic area	1.2149	0.7449	1.3069
North coastal comprehensive economic area	1.0972	0.6807	1.1746
East coastal comprehensive economic area	1.0858	0.9902	0.9374
South coastal comprehensive economic area	0.6616	1.4070	0.0000
Yangtze River middle-reach comprehensive economic Area	1.1779	0.7485	1.2484
Yellow River middle-reach comprehensive economic area	1.3139	0.5421	1.6007
Large southwest comprehensive economic area	1.2757	0.6042	1.4988
Large northwest comprehensive economic area	1.4074	0.4319	1.8203

Table 7 Evaluation result of growth capacity of high-tech enterprises

Economic area	Index C	Ranking
South coastal comprehensive economic area	0	1
East coastal comprehensive economic area	0.9374	2
North coastal comprehensive economic area	1.1746	3
Yangtze River middle-reach comprehensive economic area	1.2484	4
Northeast comprehensive economic area	1.3069	5
Large southwest comprehensive economic area	1.4988	6
Yellow River middle-reach comprehensive economic area	1.6007	7
Large northwest comprehensive economic area	1.8203	8

situation of high-tech enterprises lags behind the excellent-class growth capacity area, however, with some advantages [15].

3. Poor-class growth capacity area: with osculating value greater than 1.5, including Yellow River Middle-reach Comprehensive Economic Area and Large Northwest Comprehensive Economic Area, where the growing situation of high-tech enterprises is poor and the situation is not optimistic.

4 Conclusion

An osculating value method is used in the evaluation of growth capacity of high-tech enterprises in the regional innovation system in the paper, eliminating the evaluation deviation caused by subjective factors to avoid the relevance issue between indexes, featuring simple and clear calculation process, strong operability and feasibility and scientific and fair evaluation results, which makes it a simple optimal method for evaluation of growth capacity of high-tech enterprises [16].

The comprehensive evaluation and analysis of eight comprehensive economic high-tech enterprises provide corresponding ideas for the construction of a regional innovation system and the development of regional economy in China:

1. Excellent-class growth capacity area: maintain the leading position, elevate comprehensive technical content of products, actively conduct independent innovation, improve the continuous innovation capacity of high-tech enterprises and bring into full play the competitive advantages of high-tech enterprises at the same time, integrate various regional resources [17], make use of the agglomeration effect of high-tech enterprises and fully pull the rapid development of other relevant industries in the regional innovation system.
2. Fair-class growth capacity area: on the one hand, actively learn development experience from the excellent-class growth capacity area, implement effective measures conducive to the growth of high-tech enterprises, but on the other hand, have to courage to conduct management innovation, market innovation and technical innovation, actively improve the market environment and enterprise interior environment, improve the market competitiveness [18] of enterprises and gradually narrow the gap between the fair-class growth capacity area and the excellent-class growth capacity area [19].
3. Poor-class growth capacity area: actively improve backward situation, find out the bottle neck faced by the development of enterprises, positively create conditions to make breakthroughs and meanwhile select high-tech industrial fields based on the local advantageous environment, realize priority breakthroughs and cultivation and practically enhance the R & D capacity and comprehensive strength of high-tech enterprises [20]. At the same time, bring into full play the service role of the government in the regional innovation system, strengthen the support for high-tech enterprises and provide power policy support.

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Determinants of Revenue of Personal Income Tax in Vietnam

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Abstract Revenue of personal income tax has been accounting for a higher and higher proportion in Vietnam's total tax revenue. The purpose of this article is to combine some different methods to find the causes of this issue. The authors find that the growth rate of this tax depends on economic growth, perfection of tax law, professionalism of the tax authority system and some other factors. In which the increase of GDP/GDP per capita is the most important factor. In addition, the authors also find that the annual average burden of this tax in the applied period of the Ordinance is nearly 2.34 times lower than the applied period of the Law.

Keywords Economic growth • Personal income tax • Tax collection • Tax burden

1 Introduction

The application of the personal income tax occurs in two trends: firstly, if the personal income tax burden is reasonable, it will be likely to stimulate economic growth and increase the state budget revenues; secondly, if the personal income tax burden is excessive, reverse effects will be likely to appear [1]. Thus, many

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economists will agree with the ideal of "high taxes are bad for economic growth". However, the evidences found in many studies shows that this ideal is not necessarily obvious, either in theory or in the data [2].

Vietnam also has applied the personal income tax Law. When this Law comes into effect, revenue has been increasing constantly over the years. Nevertheless, the personal income tax Ordinance for high-income earners was applied before 2009, its perfection level was not secured, revenue from this tax was lost. The loss of tax revenue is also due to the tax evasion initiative of many subjects. The recent research on enterprises in some provinces of Vietnam also showed that the tax evasion was very popular in the private enterprises without official registration [3, 4].

The purpose of this article is to clarify the influence of factors for the personal income tax revenue. Simultaneously, this paper proves two hypotheses: Firstly, citizens were overburdened by the personal income tax in recent years. Secondly, the average tax burden in the implementation period of the Ordinance is lower than the implementation period of the law.

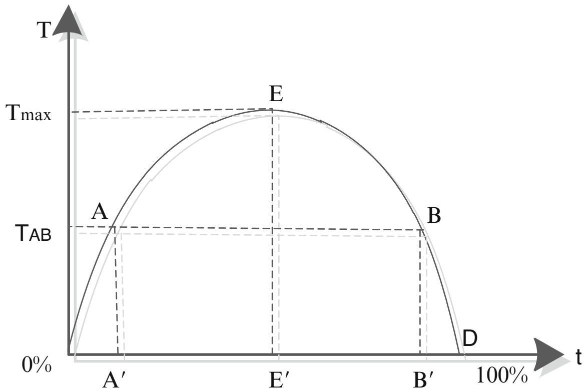
2 Theoretical Framework

Tax collection is to increase the State budget revenues to meet the spending demands of Government. The spending demands of Government also aim to regulate the society and the economy to be in the right way and develop to higher ladders. However, the sphere of influence of taxes not only consider who will bear the tax burden, but also pay attention to who will receive benefits from expenditures funded by tax revenues [5]. For each country, it is hard to determine how much the tax burden level is optimal. In fact, so far, the optimal tax theory provides little practical guidance to determine a reasonable tax rate for a country [6]. Within the scope of this article, the authors will introduce the main contents of the Laffer curve theory that the authors have introduced in another article [7], and now would like to use the entire contents of which.

The supply side economics expressed perspectives aiming at using tax instruments to stimulate economic growth. Delegate for the supply side economics is A. Laffer economist. He gave the theoretical curve reflecting the dependence between tax rate and total tax revenue, called the Laffer curve. Based on the theoretical curve, A. Laffer proved that raising taxes in America had had a negative impact on the social production. From the critical analysis, the author of the doctrine concluded: with the tax rate determined reasonably, total tax revenue is maximized. Specifically see Fig. 1 below:

In the Figure of the Laffer curve, the vertical axis shows total tax revenue (denoted by T), the horizontal axis shows tax rate (denoted by t). At the point O, the tax rate is 0 %, achieving the highest consensus of society, but the Government does not get any tax money. When the government applies the tax rate at the point A′, the growth rate of tax revenues is the highest, total tax revenue of the Government is T_{AB} corresponding to the point A located on the Laffer curve with the people's consensus

Fig. 1 The Laffer curve



reach. When the tax rate rises from point A′ to point E′, the total government's tax revenue is the highest (T_{max}) matching with the equilibrium point E, but the growth rate of tax revenues is declining, and the consensus of the people reduces up. If the government applies excessive tax burden, the tax rate is beyond the point E′, the total tax revenues of the government are not only without increase but also decrease with sharp fall in the consensus of the people. Also, the pressure on high tax costs makes the scale of investment, production and business narrow, so economic growth decrease. If the government taxed at the point D corresponding to 100 % tax rate, the Government would not get any tax money, because the activities of investment, production and business of the society are suspended.

3 Overview Analysis

3.1 Determinants

The efficiency of total tax revenue collection in overall and the personal income tax revenue collection of Vietnam in particular have been enhanced in terms of both quantity and quality. Although the effective level was not achieved as expected, the loss of tax revenue has been happening, many new income sources have not to be added into the Law etc., the tax law still has gained some certain achievements over the years. Nevertheless, the causes of these problems include:

Firstly, Vietnam is a country with relatively high GDP growth rate, thus, the income per capita has also increased rapidly. The fact shows that there is such a high part of the population who does not only get a living standard for each individual and all family, but also retain capital to save or re-investment, or in many cases these kinds of incomes are not subject to pay the personal income tax. Also, due to the rapid development of the Vietnamese economy, many new jobs have been generated, from that the people have more opportunities in finding a job and raising income.

Simultaneously, the slow adjustment in terms of the reduction level of taxpayers and family-circumstance reduction level, according to the change of actual expenditure demand and the rise of the consumer price index, leads to an increasing number of taxpayers and people who are arranged into a higher tax rate level. Thus, reality in Vietnam in recent years has shown that the personal income tax revenues have been increasing mainly thank for the economic growth and GDP per capita.

Secondly, the personal income tax Law has been increasingly perfected. Especially, since 2009, the high-income tax Ordinance replaced by this tax Law, many new income sources has been adjusted in the Law that previously the Ordinance has not adjusted, such as income from franchise transfer activities, prize-winning, promotion programs, gifts, etc. In addition, the personal income tax Law has also received a number of incomes (income from business activities, income from the transfer of real estate, etc) from other tax laws (tax on corporate income, tax on transfer of land use right).

Thirdly, the organizational structure of the tax authorities is increasingly geared towards the professional, so the effectiveness of tax collection and tax revenue management is up. Especially, Vietnam has been developing the system of tax agents and to be implementing several measures to improve the operation capability. The tax agents have continuously contributed to the improvement of efficiency of the tax revenues generally and the personal income tax revenues particularly. However, up to now, Vietnam has only 83 tax agents, 935 people having professional certificates. These numbers are too small compared to the target of 2015 in which the whole country will have 3,000 tax agents with about 24,000 employees corresponding under the plan of tax system reform in period 2011–2015 [8].

Fourthly, the application of information technology for the collection and the management of the personal income tax revenue are also gradually improved. The requirements for reporting and statistic are arranged in a systematic way. Long time in the Vietnamese society, the economic transactions have mainly conducted in cash, affecting the personal income tax collection. Nevertheless, in recent years, this traditional payment method is gradually replaced by payments through banking systems, therefore, the incomes of citizens are under tightly control, contributing to the avoidance of the loss of revenue sources. Vietnam has been actively reforming administrative procedures and innovating tax management process in recent years, making the amount of voluntary taxpayers increased, which in turn helps to raise the personal income tax revenue, etc.

Fifthly, there is another important factor affecting the personal income tax collection, which is consumer price index (CPI). However, according to the research of the authors, CPI was not clearly having an impact on total revenue of this tax. Because, practice in Vietnam, in the implementation period of the Ordinance or the Law, the reduction level was not adjusted according to the fluctuation of CPI, so CPI seems to be disabled. For example, from 2009 to present, the personal income tax law began to replace the high-income tax ordinance, the deduction level which is VND 4 million/month (48 million/year), for one taxpayer and 1.6 million/month for one dependent still does not change. While the first 2 years of implementation

Table 1 The personal income tax revenue of Vietnam

	2010		The first 6 months of 2011	
Indicators	Billion VND	Rate %	Billion VND	Rate %
Total:	26,128	100	19,281	100
Revenue from salary, wage	19,326	73.94	15,235	79.00
Revenue from production and business	1,359	5.20	746	3.87
Revenue from capital investment	660	2.52	732	3.79
Revenue from capital transfer	205	0.78	82	0.42
Revenue from transfer real estate	3,394	12.98	1,846	9.59
Revenue from prize winning	1,126	4.30	599	3.11
Revenue from copyright	8	0.03	4	0.02
Revenue from inheritance, gift (excepted real estate)	10	0.038	2	0.01
Other	40	0.15	30	0.16

Source: General Department of Taxation, Vietnam

(2009, 2010), the CPI has increased by nearly 18 %; if to calculate from the beginning of construction of the Law, the CPI has risen over 54 % [9]. Thus, we can eliminate this factor from those affecting the personal income tax revenues. However, this factor has explained relatively clearly that Vietnamese citizens are overburdened by the personal income tax law. The inadequacies of the current personal income tax law are creating an image of an artisanal and unfair tax law [10]. To prove this assertion, we see the data Table 1 above.

Table 1 shows us the following three highlights: *First,* the personal income tax law of Vietnam in recent years has still not ensured social justice, because the number of 75 % of tax revenues from salaries, wages is too high, while all the remaining revenues are only accounted for about 25 % of total personal income tax revenues. *Second,* the fact shows that although incomes from production and business activities are so much, Vietnam has still not exploited effectively these revenues, causing losses of tax revenues. *Third,* since tax revenues are mainly from salaries, wages, the deduction level is too low compared with the demand of reality. Meanwhile, the CPI has increased rapidly in recent years, so the personal income tax Law of Vietnam showed artisanal.

To solve this issue, Vietnam has made a suitable response by adjusting the deduction for taxpayers from VND 4 million/month (VND 48 million/year) to VND 9 million/month (VND 108 million/year), increasing 225 %; family circumstance reduction for each dependent from VND 1.6 million/month to VND 3.6 million/month, increasing 225 %. These changes will be officially applied on 07/01/2013. Certainly with these deduction levels, the living standard, saving or re-investment ability of citizens can be improved compared to previously. However, the effect of this action is the immediate reduction of state budget revenues. After applying the deductions above, the tax regulation levels are expected reduced at all levels. In which 100 % of the taxpayers at level 1 will be tax-free, 72 % of the taxpayers at level 2 will be switched to level 1, and so as for all remaining

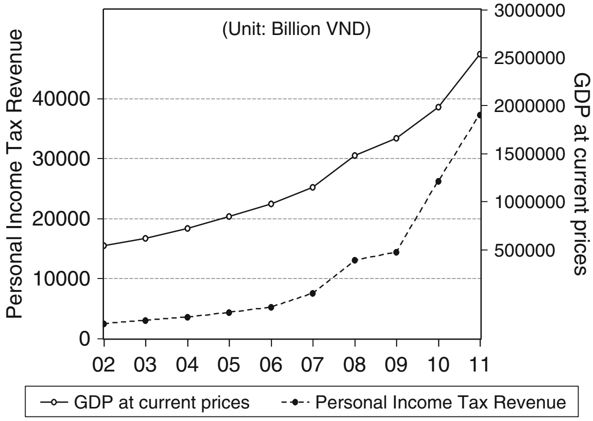


Fig. 2 GDP at current prices and Personal Income Tax Revenue in Vietnam during the period 2002–2011 (*Source*: General Department of Statistics and Ministry of Finance)

levels. The state budget is reduced about VND 5,200 billion in the last 6 months of 2013 and about VND 13,350 billion in 2014 [11]. This actual problem happens in a developing country like Vietnam also consistent with the theory of A. Laffer.

3.2 The Relationship Between GDP and Revenue of Personal Income Tax

In this article, the authors will mainly focus on how the GDP impacts on the personal income tax revenue. Because even if other factors are perfect and GDP does not reach a high level of growth, so average income of citizens is also difficult to cover for both the full living expenses and tax payment.

Practice in Vietnam shows that the value of GDP and the personal income tax revenue have increased rapidly in both absolute and relative numbers. Review on relative values, the personal income tax revenue in 2002 increased about 21.23 % compared with 2001, similarly 2003 increased about 26.22 %, 2004: 19.32 %, 2005: 20.25 %, 2006: 22.32 %, 2007: 43.17 %, 2008: 74.51 %, 2009: 10.65 %, 2010: 83.6 %, and 2011: 41, 36 %; the annual average rate of the period 2002–2011 was about 36.26 %. Also during this period, the GDP growth rates were all positive numbers ranging from 6.0 to 8.5 %. The specific data for each year: 7.08, 7.34, 7.79, 8.40, 8.23, 8.46, 6.31, 5.32, 6.78, 5.89 %. Such high growth rates like that have become the most important reason for the increase of the income per capita. The average of the period 2002–2011 increased about 17.32 %, specific data for each year: 14.21, 13.17, 15.18, 15.99, 14.76, 16.21, 27.89, 10.97, 18.21, 26.64 %. Through the analysis of these data, we can see that the average growth rate of the personal income tax revenue in the period 2002–2011 was higher than the growth rate of GDP and GDP per capita. Thus, the excessive personal income tax burden has been happening in Vietnam. Review on absolute value, we see the following Fig. 2.

If we compare the implementation phase of the high-income tax ordinance (2002–2008) and the personal income tax law (2009–2011), we will see a large difference. The annual average growth rate of tax revenue in the period 2002–2008 was 32.43 %, in the period 2009–2011 was 45.20 %. Corresponding with the two above phases, the annual average economic growth rate was approximately 7.65 and 5.99 %, the annual average growth rate of GDP per capita was about 16.77 and 18.61 %. From this analysis, we can conclude that the personal income tax burden is different between the two phases, the average tax burden of the applied period of personal income tax law was higher than the applied period of high-income tax ordinance.

4 Empirical Analysis

4.1 Model and Results

The OLS method is applied to perform an analysis on the simple linear regression between total personal income tax revenue and GDP at current prices in Vietnam. In which GDP at current prices is an independent variable, total personal income tax revenue (TAX) is dependent variable. The time period is from the year 2002 to the year 2011. The data sources are from the Ministry of Finance and the General Statistics Office. The regression model has the following format:

$$\mathrm{TAX_t} = \hat{\beta}_1 + \hat{\beta}_2 \mathrm{GDP}_t + \mu_t \tag{1}$$

The authors use Eviews software. After conducting, the table of regression results shows that the value d of Durbin-Watson test is 0.776947. While the sample numbers $n = 10$, number of independent variables in the model k' is 1, inferring $d_L = 0.879$ and $d_u = 1.320$. Due to $d < d_u$, the model has the autocorrelation phenomena grade 1. Therefore, we need to test autocorrelation phenomena based on the consideration of the remainder e_t depends on its latency or not. The autocorrelation test grade 1 by the accessories regression.

The model has not the block coefficient:

$$\varepsilon_t = \alpha_1 \varepsilon_{t-1} + \upsilon_t \tag{2}$$

The model has the block coefficient:

$$\varepsilon_t = \alpha_0 + \alpha_1 \varepsilon_{t-1} + \upsilon_t \tag{3}$$

Regression results of the model (2):

$$\mathrm{E}\,(-1) = 0.552144, \quad \mathrm{DW} = 1.502491$$

Regression results of the model (3):

$$\mathrm{E}\,(-1) = 0.544125, \quad \mathrm{DW} = 1.499157$$

The autocorrelation phenomena will be overcome by using the general differential equation:

$$\mathrm{TAX}_t + \hat{\rho}\mathrm{TAX}_{t-1} = \hat{\beta}_1\left(1-\hat{\rho}\right) + \hat{\beta}_2\left(\mathrm{GDP}_t - \hat{\rho}\mathrm{GDP}_{t-1}\right) + \left(\mu_t - \hat{\rho}\mu_{t-1}\right) \quad (4)$$

Through the DW statistics and the accessories regression of two models (2) and (3), the correlation coefficient estimation grade 1 $\hat{\rho} \cong 0.55$, to substitute into the general differential equation (4):

$$\begin{aligned}\mathrm{TAX_t} + 0.55\mathrm{TAX}_{t-1} = \hat{\beta}_1\,(1-0.55) + \hat{\beta}_2\,(\mathrm{GDP}_t - 0.55\mathrm{GDP}_{t-1}) \\ + (\mu_t - 0.55\mu_{t-1}) \quad (5)\end{aligned}$$

After performing the operation, the regression equation of the form:

$$\mathrm{TAX_t} + 0.55\mathrm{TAX}_{t-1} = -6{,}678.297\,(1-0.55) + 0.020162\,(\mathrm{GDP}_t - 0.55\mathrm{GDP}_{t-1}) \quad (6)$$

t = (−4.191801) (10.10961)
p_value = (0.0041) (0.0000)
$R^2 = 0.935900$
F-statistic = 102.2043
Durbin-Watson = 1.894767

According to the results of this regression, the differential model has not autocorrelation phenomena grade 1. The p_value is too small compared to the significance level α = 5 %. The mark of the block and slope coefficients of the differential model is consistent with the economic rule. After the change of variables, the block coefficient estimate of the differential model is −6,678.297, therefore the block coefficient estimate of the model (1): $\hat{\beta}_1 = [-6{,}678.297/(1-0.55)] = -14{,}840.66$, the slope estimate of the original model $\hat{\beta}_2 = 0.020162$. Thus, the model (1) takes the following form:

$$\mathrm{TAX} = -14{,}840.66 + 0.020162\,\mathrm{GDP} \quad (7)$$

Conclusion: For $\hat{\beta}_1$, when the economy does not work, the GDP value by 0, income per capita also by 0, the personal income tax revenue by 0. For $\hat{\beta}_2$, with 95 % reliability, considering an average year in the period 2002–2011, when GDP at current prices was increased up 1 billion VND, the personal income tax revenue would increase 0.020162 billion VND.

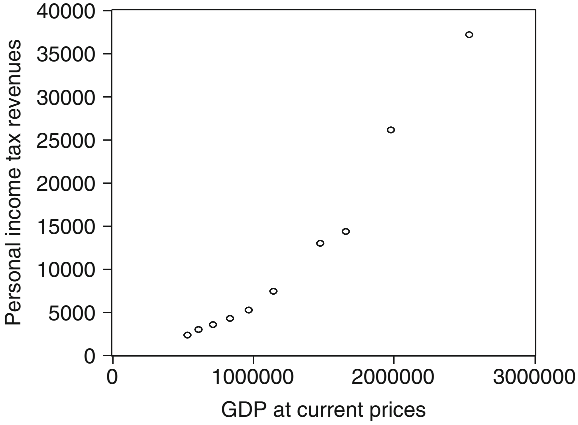


Fig. 3 Determination of qualitative variable

4.2 Testing When the Independent Variables Are Added into the Original Model

We will draw the graph of Y by X (Fig. 3).

The graph of the first phase from 2002 to 2008 (corresponding to 7 left points) is less steep than the later period from 2009 to 2011 (corresponding to 3 right points). This also coincides with the two periods analyzing above: the application period of the high-income tax ordinance and the application period of the personal income tax law. Thus, due to the period factor is qualitative, we will add a dummy variable in the regression model .

Set D is dummy variable: D = 0 with the observation 2002–2008. D = 1 with the observation 2009–2011. The regression model of the form:

$$\text{TAX} = \hat{\beta}_1 + \hat{\beta}_2\,\text{GDP} + \hat{\beta}_3\,\text{D} + \hat{\beta}_4\text{D} \times \text{GDP} + \mu_t \tag{8}$$

The first period:

$$\text{TAX} = \hat{\beta}_1 + \hat{\beta}_2\,\text{GDP} + \mu_t \tag{9}$$

The later period:

$$\text{TAX} = \left(\hat{\beta}_1 + \hat{\beta}_3\right) + \left(\hat{\beta}_2 + \hat{\beta}_4\right)\,\text{GDP} + \mu_t \tag{10}$$

The authors are using Eviews software. But in the Eviews program, the D dummy variable name is not accepted, so to use the name is D1.

The regression equation (8) has the form:

$$\text{TAX} = -4{,}245.822 + 0.010841\ \text{GDP} - 22{,}139.31\ \text{D} + 0.014548\ \text{D} \times \text{GDP} \tag{11}$$

The regression equation (9) has the form:

$$\text{TAX} = -4{,}245.822 + 0.010841\ \text{GDP} \tag{12}$$

The regression equation (10) has the form:

$$\text{TAX} = -26{,}385.132 + 0.025389\ \text{GDP} \tag{13}$$

t = (−2.55364) (6.191260) (−4.428682) (5.094612)
p_value = (0.0000) (0.0008) (0.0044) (0.0022)
$R^2 = 0.990099$
F-statistic = 200.0078
Durbin-Watson = 2.800471

The data in the table of regression results show that the mark of the block and slope coefficients of the differential model is consistent with the economic rule. The p_value is too small compared to the significance level $\alpha = 5\ \%$. According to the results of this regression, the model has not the positive autocorrelation phenomena grade 1.

Conclusion: For the period 2002–2008, $\hat{\beta}_2 = 0.010841$ indicates when GDP at current prices increases VND one billion, the personal income tax revenue will increase VND 0.010841 billion. For the period 2009–2011, $\hat{\beta}_2 = 0.025389$ shows when GDP at current prices increases VND one billion, the personal income tax revenue will increase VND 0.025389 billion.

From the two above conclusions, we can confirm that when GDP at current prices increases by one billion, total average tax revenues for the period 2002–2008 will be about 2.34 times lower than that of the period 2009–2011. This means that the personal income tax burden when the tax law is implemented is higher than that of the implementation of the tax ordinance.

5 Conclusion and Discussion

The findings of this article are suitable with the theoretical model of A. Laffer. The theory curve of A. Laffer pointed out that when the government overburdens citizens with tax lasting for a long time, this, in turn, will have bad impact on the economy and society. Practice in Vietnam has proved took that in recent years.

The personal income tax burden of Vietnam is the highest tax burden compared to other countries in the region or not? For this issue, the authors will study in the relationship with other countries, especially countries with similar developmental conditions.

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The Research of Inter-firm Network Organizations' Embedded Risk Based on Grounded Theory

Zheng-yin Peng and Tian Cao

Abstract Asymmetric information and bounded rationality of individuals, bring the firm network organization a number of risks, influence individual and a good run in the network organization and overall network efficiency improvements. The paper enable people to have in-depth knowing and more comprehensive with the phenomenon of embed risk in firm network organizations, providing members guidance. This study begins with the perspective of network organizations embedded, taking CNRO Science-Technology Development Co. Ltd. as an example to have three research, collecting a certain depth and breadth of the scientific method in accordance with grounded theory, the information of CNRO collected, posted 175 labels given to the concept and tagged 103 referential phenomenon, and construct the 103 expression of the concept of a theme words, and finally, the essay extracted from the 61 areas, namely, the second class keywords. In the course of the study, analysis each decoding the data, the conclusion that the theory rooted in the data extracted from the network organization are four main embedded risk.

Keywords Embedded risk • Grounded theory • Inter-firm network organization

The cooperation between the modern firm has a prominent network features, there is no internal mandatory and authority, and it's impossible to be control by price mechanism itself. The relationships between the members of the network mainly relay on informal price mechanism to coordinate. Thus, it poses a potential threat to the network operations. In the firm network embedded process, the uncertainty of the individual as well as the overall, and the degree of information sharing, the complexity of the various factors, all of them lead to the generation of network risk

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and its superposition. If firm network organization want to enhance competitiveness, and enhance their own ability to resist risks, first of all is to explore the state of risk that may exist in the network organization embedding process.

1 Embeddedness and Network Organizations Embedded Risk

Embeddedness including relation embedded and structure embedded. Relation embedded is that network participants, based on the quality of bilateral trading, on account of reciprocity expectation, attach importance to each other's demand, target extent and behavior in the course of action (Such as credit, trust and information sharing on) [1]. It emphasizes the function of direct connection, that as a mechanism for the exchange of high quality information [2–5]. Structure embedded includes network density, network size, intermediary, centrality and so on structure variables. Coleman [6] believes that the high-density network interconnected restricts the behavior of members and lead to cooperative behavior [6]. Firms within an industry, who have links to each other, form a network called "closed network". In such a high-density network irregularities behavior information will spread rapidly [7], Governance mechanisms cannot be generated to prevent opportunistic. Too high the center of the network groups will produce the negative effects. Uzzi [4] believes that the discomfort structure embedded will cause a performance declining [4]. Once the competitive activity begins, the center firm in the network location will get advantage. Resources Priority will reduce its competitor's reaction [8, 9]. This leads non-center firms face the risks of difficult to joint assets or plan a confronting program. At the same time due to lack of information, the noncentral firm is difficult to comprehend the causes and results of the competitive behavior [10]. This lack of reaction will further stimulate the center firm to launch competitive behavior [11, 12]. Although Burt [13] stressed the benefits of structural holes, Ahuja [14] found in the focal firm network, at least in the cooperation between the organization's network. The increase or decrease in the structural holes have a negative impact on firms innovation performance, the more structural holes, the less firms obtain patents [15].

The paper analyses the related literature of network organization risk. Domestic and foreign scholars from different research perspectives described some of the risks that exist in the network organization, as shown in Table 1.

Invoking the transaction cost theory, principal-agent theory, social network theory; this study suggests that in the process of firm network organizations embedded, as a member of the network organization with limited rationality, opportunistic behavior can't be avoided. One of the root causes of opportunistic behavior is asymmetric information [31]. Information asymmetry lead the degree

Table 1 Firm network organizations risk

Risk performance	Research purposes		Author and year
Production conditions, firm product and service quality, inadequate grasp of the information, etc.	Asymmetric information aspects	The contract incomplete produced prior opportunistic behavior; Network organization cooperation game processed, etc.	Parkhe [16], Dahlstrom et al. [17], Arrow [18], etc.
Product and service quality fraud; technical loss; evade responsibility speculative behavior; Deceive each other to obtain the benefits, etc.		Network organization produces opportunistic behavior, e.g. hitchhiking, fraud, lazy behavior; Moral hazard, etc.	Quintas et al. [19], Anderson [20], Arrow [18], etc.
Innovation bondage; Cognitive convergence between partners; Embedded excessive lead relationship stuck; Breach of contract or redraft the contract, etc.	Embedded aspects	The Network Entity excessive embed produce negative effects; Excessive embedded lead the path dependence, regional lock, blackmail, etc.	Burt [13], Hakansson and Snehota [21], Williamson [22], Wathne and Heide [23], etc.
Information technology spillover; Distribution of income uncertainty;		Spillover effects;	Faulkner [24], Chen [9]
New firms bring competition intensifies; Speculation, etc.		Resource dependency; vicious competition; pseudo collaborative, etc.	Chen and MacMillan [12], Zaheer and Venkatraman [25]
High exit costs, conversion costs; Increased transaction costs offset the cooperation benefits; Partners locked, etc.		Costs brought about by unstable network organization; Collaborative rigidity and instability of the network organization.etc.	Coleman [26], Gulati [27], Wathne and Heide [23], Wangli and Shijintao [34], etc.
Supply chain "domino effect." Information distortion, distorting the information, etc.	Conductivity aspects	"bullwhip phenomenon " of supply chain network connectivity of the network nodes; restrict the behavior of members of high-density network, etc.	Hakansson and Snehota [21], Inkpen [28], Uzzi [4], Anderson [20], Ouchi [29], Pablo [30], Coleman [6], Gnyawali and Madhavan [10], etc.

of information sharing high or low, which will lead to corporate behavior of members of unobserved [32]. In the process of Embeddedness will appear withhold information, distorted information, lazy, free-riding opportunistic behavior.

2 Firm Network Organization Embedded Risk Case Analysis Based on Grounded Theory

Firm network organizations embedded risk is a process of research, it involves scenario matching, elements interact and laws of logic in different embedded perspective. This paper follows the case of participatory dialogue skills – three field research in CNRO, collected some of the information and use grounded theory to analyze.

2.1 Case Selection and Data Collection

The research ideas of the paper as follow, grounded theory analysis: Firstly, fully understand the course of development of the company; secondly, Conduct interviews, gather information through the pre-interview outline design; lastly, conducting on-site interviews. CNRO through several changes, finally form in itself as the center of the network organization. (1) Firm has the process of the network organization embedded. CNRO's economic activities related to various aspects of the supply chain and production operation, his production, sales, financial operations and after-sales service process, all involves embedding. He has representative and universality. (2) Firm growth process is universal. In the process of firm network organization embedded, he will face partner selection, information asymmetry, resource locking, asset specificity, and other issues. (3) The completeness and accuracy of the information. On the one hand, by partnership with CNRO, through its site visits and interviews, this paper obtained a wealth of first-hand information. On the other hand, in the cooperation of CNRO, we establish partnership, based on this relationship, we indirect access to a large amount of information that is publicly available.

2.2 Application Process

2.2.1 Open Coding

The process of pen coding is to conceptualize the code. This study strictly comply with Strauss's [33] five basic criteria of open login. Continue to supplement and improve take notes while information verbatim decomposition. By using the words of the respondents, excerpting concept from the literature or directly naming concept to decode. Then summarize generic. Decompose the information to be collected, Post 175 tags. Then, each tag reflects an phenomenon, summary it on line. This will lay the foundation for the concept. At last, this paper give 103 concept to the referential phenomenon on the label, construct 103 key words to express the concept, extracted 61 areas (AA_1–AA_{61}), that is secondary key words. Due to space constraints, only list partially open coding as an example, shown in Table 2.

2.2.2 Spindle Decoding

After completing open coding, the paper forms 61 areas. That is composed of a large class of secondary key words. In the process of Spindle decoding, according to founded theory, with decoding canonical model, we analyze the conditions of phenomenon, context, action/interaction strategies and results, link various aspects. We subdivide and refine the key words, and put back data together again. This paper developed four main areas that is contractual risk, lock risk, negative reciprocity risks, conductivity risks.

1. Main areas – contractual risk

Through Table 3 above canonical model, the paper shows the nature of the relationship between the main areas of contractual risk with other sub areas, conceives hypothetical relationship between the main and auxiliary areas. This hypothetical relationship builds to think they each referential abstract nouns, that is, whether a relationship exists between the areas. When the hypothesized relationship is established, but also need to verify the information in the story, to confirm whether to support or disprove hypotheses relations. To this end, this paper established a chain of evidence (Fig. 1) to verify the relationship between the scopes of the canonical model.

2. Main areas – Lock risk

Interview data is able to verify the relationship in the above-described canonical model (Table 4). Evidence chain construct shown in Fig. 2.

3. Main areas – negative reciprocal risk

Interview data is able to verify the relationship in the above-described canonical model (Table 5). Evidence chain construct shown in Fig. 3.

4. Main areas – conductivity risk

Interview data is able to verify the relationship in the above-described canonical model (Table 6). Evidence chain construct shown in Fig. 4.

Table 2 The process of open coding

Interviews and participant observation data in CNRO	Open coding			
	Phenomenon summary	Conceptualization	Standardization	Categorization
…	…	…	…	…
Mr. Guo also mentioned: before signing the contract, it is not very clear to master the cost of some firms, (a_{28})	a_{28}: Do not understand the cost of the firm	aa_{25}: get the support of multiple resources in CNRO's development process (a_{39} a_{41} a_{100} a_{139} a_{141})…	A_{25}: gain resources	AA_{17}: Low level of information sharing (aa_{27} aa_{28})
Not too much information about the firm to introduce CNRO (a_{29})	a_{29}: Firm passed less information to CNRO	aa_{30}: Product quality problems (a_{50} a_{52})	A_{26}: Signing contracts…	AA_{18}: true level of products and services (aa_{30})
Just listen to the counterparties verbal descriptions and commitment of the counterparties products, technical level and quality of service. (a_{30})	a_{30}: The counterparties technology is verbal commitment	aa_{31}: Partner's commitment (a_{31})	A_{30}: real level of product and service	…
Facing some financial problems due to the start-ups, (a_{31})…	a_{31}: Start-up firm are facing funding problems	aa_{32}: Re-select partners (a_{53})	A_{31}: Partner's commitment	AA_{19}: Abandon cooperation, decisive exit (aa_{32})
CNRO signed a contract in the case of lower grasp of the information, (a_{35})	a_{32}: No economic reserves, facing financial pressure…	aa_{33}: The damage after signing contract (a_{54})	A_{32}: Abandon cooperation, re-select partners	AA_{20}: Contractual risk (aa_{21} aa_{33} aa_{29})
Some companies use false sincerity to get CNRO's trust after the contract signed (a_{36}) …	a_{35}: Acquire less information to sign contract	aa_{34}: Emphasis on information exchange before signing (a_{55})…	A_{33}: Contract incompleteness damage	AA_{21}: Information sharing (aa_{34} aa_{59})…
	a_{36}: Utilize the false sincerity obtain trust contract, …	A_{34}: Pre-contractual information exchange …		

Table 3 Canonical model

Causal condition	Incomplete contract (AA_{13})	Phenomenon	Contractual risk (AA_{20})
The nature of causal condition		**Contractual risk characteristics**	
Not high awareness of cost (AA_{11})		Awareness of business conditions	Not high (AA_{11})
Level familiarity of products, technical (AA_{15})		Products, technology and quality disclosure	Inadequate (AA_{15})
Less firm messaging (AA_{12})		Degree of information sharing	Low (AA_{17})
Lack of marketing, resource channels (AA_{49})		Late cooperation in resource inputs	Inadequate (AA_{49})
Quality of products, services spoofing (AA_{16})		True level of products and services	Low (AA_{18})
Products, technology innovation inert (AA_{51})		Products, technology innovation	Low (AA_{51})
The partners' contribution can't distinguish (AA_{48})		Define both sides effort	Fuzzy (AA_{51})
"contractual risk" action context			
Contractual risk is the results of incomplete contract. The incomplete contract time point divided, can be divided into the leases were signed before the contract is not complete and the leases were signed after the contract is not complete. Before contract signing, both sides are not high awareness of operating conditions, financial condition and the degree of product quality, the level of information sharing is low. After contract signing, due to the incompleteness of the contract, in the allocation of resources, the actual product quality and service levels, there is speculative behavior. In addition, in the process of cooperation, the loss of the core technology, that presents free-riding behavior in product technology innovation. Unable to share contribution revenue clearly. Under the conditions of incomplete contract, v low level of information sharing, that produces contractual risk.			
Intermediary conditions	The sharing of information (AA_{21}), High search costs (AA_{14})	**Action/interaction strategies**	Exchange (AA_{23}), Research (AA_{36})
Result	Conceal information, free-riding		

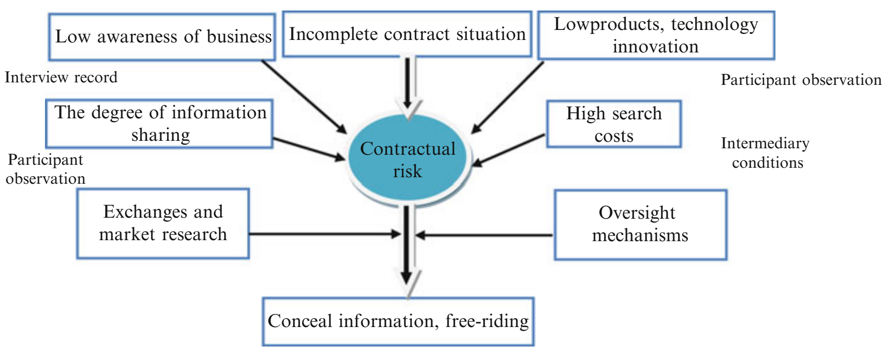

Fig. 1 Contractual risks canonical model chain of evidence

Table 4 Canonical model

Causal conditions	**Asset specificity (AA_{10})**	**Phenomenon**	**Lock risk (AA_{30})**
Nature of the causal conditions		**Lock risk characteristics**	
Difficult to be easily converted to co-partner (AA_{25})		The possibility of an important relationship stucking	Large (AA_{28})
Dependence on raw materials (AA_{50})		Resource dependence	High (AA_{50})
Requirements to **renego**tiate or re-signing contracts (AA_{31})		The possibility of contract changed midway	Exist (AA_{27})
Can not be recycled, have been put into the "sunk cost" (AA_{38})		The possibility of sunk costs	Exist (AA_{38})
The excessive specialization suffered infringement or lost (AA_{26})		The degree of technical specialization	High (AA_{35})
High switching costs or exit costs (AA_{32})		Loss of conversion or exit costs	Large (AA_{32})
"lock risk" action context			
The locking risk is generated under the following conditions: Upstream and downstream in the supply chain network, the two sides are committed to a long-term cooperation, to developing and sustaining partnerships. Asset specificity makes the parties to the transaction interdependent, can't be exchanged, and a high degree of interaction. It faces with the threat of opportunism. Under high asset specificity conditions; it's difficult for firms to convert partners. In the case of locked relations, companies have to continue the previous cooperation activities.			
Intermediary conditions	Switching costs (AA_{32})	**Action/interaction strategies**	Abandon cooperation (AA_{19})
Result	Overt blackmail acts (AA_{29})		

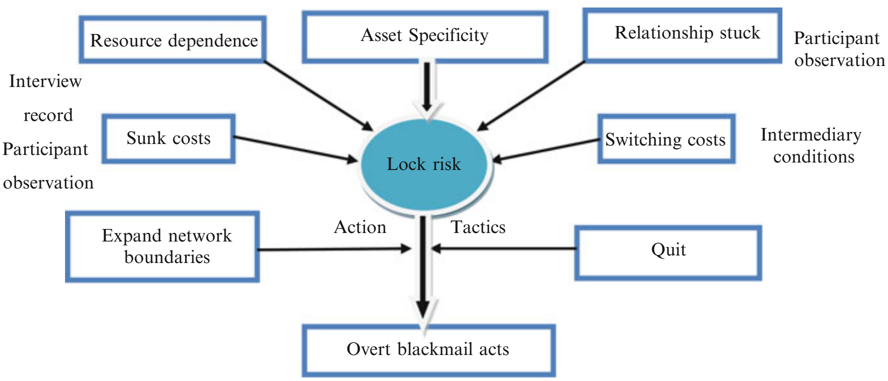

Fig. 2 Lock risks canonical model chain of evidence

Table 5 Canonical model

Causal conditions	Self-serving behavior (AA_{40})	Phenomenon	Negative reciprocal risk (AA_{47})
Nature of the causal conditions		**Negative reciprocal risk characteristics**	
Knowledge and information overflow (AA_{42})		The possibility of knowledge, technology spillover	Exist (AA_{42})
Core technology overflow (AA_{42})		New firms Entry, the degree of competition	
New firms enter the competition for resources (AA_{41})			Exacerbate (AA_{46})
"negative reciprocal risk" action context			
The negative reciprocal risk is generated under the following conditions: Reciprocity is mutual trust between the members of the firm network organization, information sharing, and the degree of interdependence. Reciprocal acts promote the formation of the core competencies and business performance. But self-serving behavior will lead malignant competition or spillover effects, produce some negative reciprocal behavior.			
Intermediary conditions	The level of trust (AA_{39})	**Action/interaction strategies**	Coordination (AA_{38}), Learning (AA_{52})
Result	Overflow risk (AA_{44})and vicious competition		

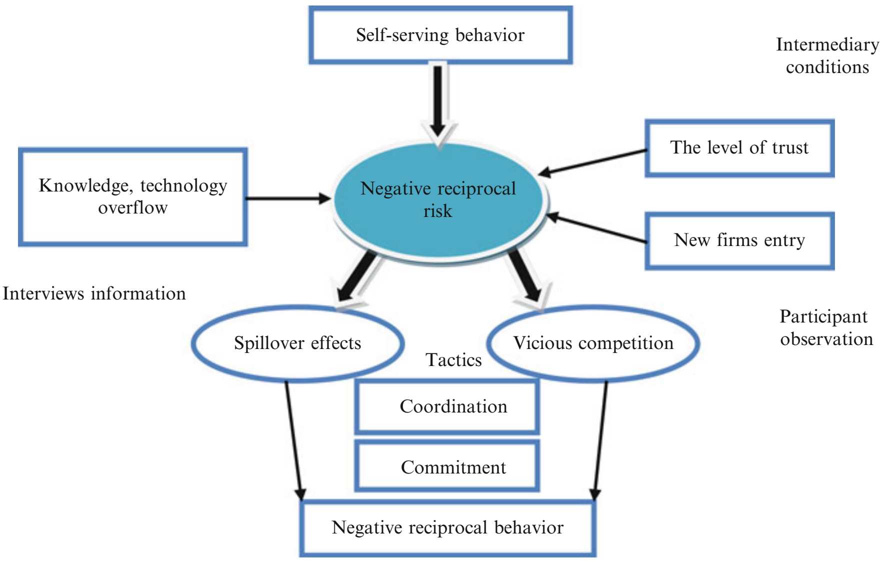

Fig. 3 Negative reciprocal risk canonical model chain of evidence

Table 6 Canonical model

Causal conditions	Information transitivity (AA_{55})	Phenomenon	Conductivity risk (AA_{59})
Nature of the causal conditions		**Conductivity risk characteristics**	
Climatic conditions of product required for the device (AA_{53})		External environment impact	Large (AA_{61})
Accidental network members Contact (AA_{54})		The strength of the cooperation	Weak (AA_{54})
The sharing of information between the partners (AA_{34})		The degree of information sharing	High (AA_{34})
Familiar with the degree of cooperation between the parties (AA_{57})		Overall interaction between network members	Not strong (AA_{24})
The accuracy of the information transfer (AA_{58})		The authenticity of the information transfer	Low (AA_{60})
"conductivity risk" action context			
The conductivity risk is generated under the following conditions: In the network, each node firms connected to each other and have decision-making ability to the flowing information. When node firms cooperate, it will produce "conflict" or "non-equilibrium". Network Shares information in specific trading activities. However, due to the interaction between the node firms is not strong, members tend to be understood and passed on the information according to their own understanding of, resulting in the risk of distortion and distorted. In particular, when a node is the status of a comparative advantage to have strong control and coordination, its risk will be starting from a node, impacts on other nodes within the firm network organization through a particular transaction or the process of cooperation. At last, it has a greater impact on the entire firm network organization.			
Intermediary conditions	Frequency of interaction (AA_{55})	**Action/interaction strategies**	Moderate embedded (AA_{43})
Result	Information distort or information distortion		

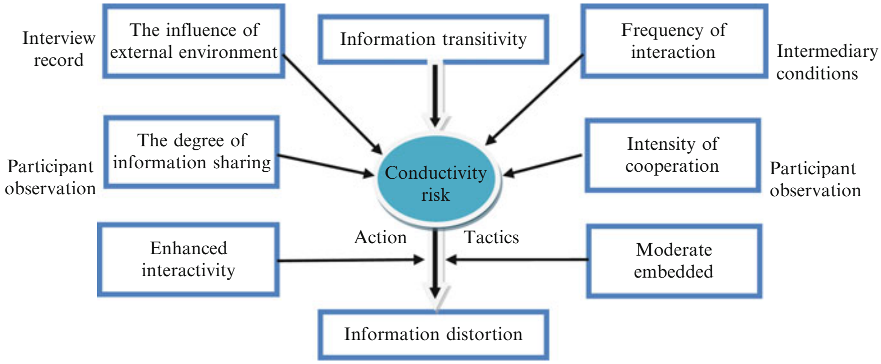

Fig. 4 Conductivity risk canonical model chain of evidence

3 Conclusion

This paper using grounded theory analysis on the information of CNRO decodes progressively, extracts 103 concepts and 61 areas from all the information. In-depth analysis of the concept and status, finally the paper shows concise four embedded risk status. The study concluded that embedded in the strength of different degree of information sharing, resulting in the generation of network organizations embedded risk. The major embedded risks are contractual risk, lock risk, negative reciprocal risk and conductivity risk.

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Research on Enhancing Long-Term Happiness: Gym Membership and Alcohol

Yuan Wang and Fan Li

Abstract The enhancement of long-term happiness is important at both an individual and societal level. Leisure is an activity that has commonly been associated with both short-term and long-term happiness. Two products that may enable consumers to engage in leisure activities are gym membership and alcohol, both of which are affordable and readily available. This paper explores consumer's motivations for consumption of both product and the relationship between gym membership, alcohol and consumer happiness. Implications for marketers and social policy makers are discussed.

Keywords Alcohol • Consumer happiness • Gym membership • Motivation

1 Introduction

The pursuit of happiness was so important that 'there is probably no other goal in life that commands such a high degree of consensus' [1]. The reason for our product choices is that most students have had experience with the gym and alcohol, and both are affordable and common. The first aim is to confirm the relationship between gym membership, alcohol and consumer happiness. Based on previous research I assumed that gym membership would be associated with a higher level of happiness than alcohol. The second aim was to investigate the motivations behind consumption of gym membership and alcohol. I assumed that gym membership would be most strongly motivated by image and physical enhancement, social interaction, relaxation and enjoyment, dependent on age and gender. By using a questionnaire which comprised questions from previous empirical studies, 102

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anonymous participants volunteered to take the questionnaire over a two week period, but 25 responses were incomplete and had to be excluded. Results confirmed the first hypothesis and partly supported the second hypotheses.

2 Literature Review

2.1 Consumer Happiness

Psychologists, economists and public policy theorists have become increasingly interested in measuring and understanding happiness among humans. Lyubomirsky et al. [2] found that the ability to be happy and contended with life is central to adaptation and positive mental health [2]. Individuals who are happy have greater self-control, and coping abilities [3], bolstered immunity [4] and tend to live longer [5]. Moreover, research suggests that happy people are more cooperative, pro-social, charitable and 'others-centered' [6–8]. Lyubomirsky et al. [3] suggested that happiness also results in a number positive tangible byproducts that benefit individuals, families and communities namely, larger social rewards and superior work outcomes [9]. In light of the above evidence, the enhancement of happiness is arguably a worthy objective.

2.2 Gym Membership

It is widely recognized that physical activity or exercise improves well-being. Exercise is considered a common leisure activity, which is facilitated by the possession of gym membership. McAuley [10] identified a positive correlation between exercise and self-esteem, self-efficacy, psychological well-being and cognitive functioning, and a negative correlation between exercise and anxiety stress and depression, suggesting long-term happiness is improved by physical activity [10]. Indeed, Dunn [11] investigated that physical activity is effective in alleviating depression [11].

2.3 Alcohol

Alcohol is also a social product typically consumed during leisure, yet the effects are decidedly more negative than that of a gym membership. Therefore, alcohol is unlikely to contribute to an individual's happiness. Harutyunyan [12] found the consumption of alcohol may result in foolish and/or dangerous behavior; alcohol consumption is associated with suicide, homicide and road-traffic accidents, as well as embarrassing behavior. Alcohol consumption is also more likely to lead to the offence of, and sufferance from, rape [13], as well as consensual yet regretted or unsafe sex [14]. It is also likely to result in detrimental social outcomes; alcoholics are more likely to become divorced, be engaged in domestic violence, be unemployed, and live in poverty [15]. Long-term alcohol exposure may also lead to the increased likelihood of infertility in women, which may in turn lead to depression [16].

2.4 Motivations

This paper will look at the motivations for the consumption of gym membership as a product resulting in positive benefits for well-being, and alcohol as a product resulting in a negative array of consequences which are ultimately detrimental to an individual's happiness. Motivations for joining the gym may vary among individuals. Crossley (2006) found that new members were mostly interested in losing weight, toning up, getting fit and enhancing their athletic performance, whereas regular gym-goers were motivated to continue doing so due to enjoyment, social interaction, relaxation and release, and a means of escape [17]. In addition, it has been examined that positive attitude towards the consequences of gym membership predicts intent to join among current members, and that motivation to comply with pressure from others predicts intent to join among non-members (or lost members) [18]. Alcohol is a common tool in the facilitation of sexual encounters, particularly amongst young people. Cooper (1994) identified four motivations for alcohol consumption; social, coping, enhancement and conformity [19]. While social and celebratory motivations for alcohol consumption are most common in the US amongst Caucasian and Latino individuals, this is not the case in Japan, or for Asian-Americans [20].

3 Methodology

1. *Participants*: 102 participants took part in the present study. The results of 25 participants were excluded due to incomplete answers. Participants were primarily students, with 27 undergraduates and 39 postgraduates. Eleven respondents were non-students. Participants consisted of 28 males, and 49 females. The median age bracket was 19–24 encapsulating 70 % (n = 54 in total) of respondents. 23 % (n = 18) of respondents were aged 25–30, 4 % (n = 3) were in the 41+ category, and 3 % (n = 2) aged 13–18.
2. *Materials*: All respondents were asked to complete a survey. Participants were initially asked to respond on demographics: gender, age group and occupation. The survey included two vignettes the first of which described the individual's

routine in going to the gym and the second a routine which involved excessive drinking. Participants had to respond 10 questions relating to happiness from the Oxford Happiness Questionnaire on a likert-scale of 1–6 [21]. Motivations for attending the gym and drinking alcohol were examined. A general introductory question was used (adapted from Haworth and Hill [22]) to ascertain a general understanding of the motivations for using both gym membership and alcohol. In order to measure specific motivations for use of gym membership, 20 questions from the Exercise Motivations Inventory [23] were used, offering respondents a 0–5 likert-scale. Finally, motivations for the consumption of alcohol were investigated. Participants were asked 20 questions relating to social, coping, enhancement and conformity motivations using a 1–5 likert scale.

3. *Procedure*: Questions were adapted from previous academic papers in order to mitigate bias, and compiled online into questionnaire format using surveymonkey.com. Effects of bias were also mitigated by using a quantitative method which is objective rather than interviews which may have caused interviewer bias. Participation was voluntary and requests for participants were by word of mouth. Data collection occurred over 2 weeks, with data stored by surveymonkey.com until the questionnaire was deactivated and data transferred to SPSS.

4 Results

(1) *Happiness*: Gym membership ($M = 4.87$, $SD = 1.03$) was found to make participants happier than alcohol consumption ($M = 3.44$, $SD = 0.89$).

(2) *Gym Membership*: Latent variables were computed using our manifest variables (Table 1). The most common motivations for using gym membership were enjoyment ($M = 3.70$, $SD = 0.97$), image ($M = 3.63$, $SD = 1.31$), relaxation ($M = 3.41$, $SD = 1.20$), and physical enhancement ($M = 3.10$, $SD = 1.05$). The least common motivations for using gym membership were social ($M = 1.55$, $SD = 0.93$), and health ($M = 1.88$, $SD = 0.73$). An independent samples t-test revealed significant differences according to demographic information. Motivation for using gym membership was found to differ significantly with gender. Males ($M = 3.53$, $SD = 0.77$) were significantly more likely to use gym membership for physical enhancement than females ($M = 2.79$, $SD = 1.09$; $t\ (75) = 3.17$, $p < .00$). Females ($M = 4.14$, $SD = 0.95$) were significantly more likely to use gym membership for image reasons than males ($M = 2.75$, $SD = 1.39$; $t\ (75) = 5.17$, $p < .00$).

A one-way ANOVA revealed significant differences in motivation for using gym membership according to age. Participants were significantly more likely to use the gym for health reasons as they increased with age; 13–18 years ($M = 1.67$, $SD = 0.94$), 19–24 years ($M = 1.75$, $SD = 0.59$), 25–30 years ($M = 2.13$, $SD = 0.97$); 41+ years ($M = 2.89$, $SD = 0.51$; $F(3,73) = 3.57$, $p < .02$). Participants were significantly more likely to use the gym for social reasons if they were in the youngest ($M = 3.50$, $SD = 1.77$) or oldest ($M = 2.50$, $SD = 0.66$) age groups than

Table 1 The variables of gym membership

Latent variables	Manifest variables
Image	To stay slim
	To control weight
	To lose weight
Physical enhancement	To stay flexible
	To measure myself against personal standards
	To increase strength
	To develop muscle
Enjoyment	It makes me feel good
	I find the gym satisfying
	I feel at my best when exercising
Relaxation	It gives space to think
	To release tension
	To manage stress
Social	To spend time with friends
	To make new friends
	To enjoy the social aspects
	To compare myself against the abilities of others
Health	To stay healthy
	Advised to go by a doctor
	To prevent an illness that runs in the family

if they were aged 19–24 years ($M = 1.45$, $SD = 0.89$) or 25–30 years ($M = 1.46$, $SD = 0.75$; $F(3.73) = 4.85$, $p < .00$).

There was no significant difference in participants' motivations for using gym membership according to occupation.

(3) *Alcohol*: Latent variables were computed using our manifest variables (Table 2). The most common motivations for using alcohol were social ($M = 3.70$, $SD = 0.80$), and enhancement ($M = 3.20$, $SD = 0.83$). The least common motivations for using alcohol were coping ($M = 2.54$, $SD = 0.88$), and conformity ($M = 2.02$, $SD = 0.93$).

There were no significant differences in participants' motivations for using alcohol according to gender, age or occupation.

5 Discussion

The aim of this study was to investigate whether consumption of gym membership and alcohol resulted in happiness or unhappiness, and the differences in consumer motivations for utilizing both products. It was assumed that gym membership would be associated with a higher level of happiness than alcohol consumption, and that sex, age would cause differing motivations for consumption of gym membership and/or alcohol.

Table 2 The variables of alcohol

Latent variable	Manifest variables
Conformity	Friends pressure you to drink
	So that others will not tease you about not drinking
	To fit in with a group you like
	To be liked
	So that you won't feel left out
Coping	To forget your worries
	When depressed or nervous
	To cheer you up
	To increase your self-confidence
	To forget your problems
Enhancement	I like the feeling
	It's exciting
	To get drunk
	It gives you a pleasant feeling
	It's fun
Social	It helps you to enjoy a party
	To be sociable
	It makes social gatherings more fun
	It improves parties
	To celebrate special occasions with friends

The results showed that participants were happier after using their gym membership than consuming alcohol, which supports my first hypothesis. It is found that the most common motivations for using the gym were image, enjoyment, relaxation and enhancement. It is also found that there were significant differences according to gender, that is, women were more likely to use their gym membership to enhance their image, while men were more motivated by physical enhancement. Furthermore, I found that there were significant differences according to age; as age increased, participants were more likely to use the gym for health reasons, and the oldest and youngest participants were more likely to use the gym for social reasons. This partially supported my second hypothesis.

The first key finding relates to the marketing of gym membership. Given the results, marketers should aim to use the above four motivations (image, enjoyment, relaxation and physical enhancement) in their communications to attract consumers. Marketers should adjust their marketing mix in order to communicate to the consumer the ways in which their needs may be satisfied. This should not be confined to advertising, but should be embodied in all communication relating to the gym, including physical surroundings, staff training and music, for example.

Given the differences according to demographic, namely age and gender, marketers should adjust their communication in line with these findings. So, in order to attract women, marketers should emphasize the ability to control or lose weight, or to stay slim. In contrast, physical enhancement motivations, such as flexibility, personal standards, increasing strength and muscle, should be highlighted in marketing to men. In addition, social motivations should be highlighted for younger and older consumers, and health should become an increasingly important focus for marketers, correlating the marketing focus on health with age. Given that gym membership was found to make consumers happier than alcohol, focus on these motivations should be employed to increase consumption of this product rather than alcohol, which appears to make consumers less happy.

At the same time, it is vital that marketers do not promote unattainable physiques. Indeed, motivations relating to health, social, relaxation and enjoyment are arguably purely positive. However, image and physical enhancement motivations may be the result of a misconception of the actual self, and an attempt to bridge the gap between this actual self and the ideal self. Marketers should be aware of this fine line between health and image, and promote the satisfaction of image and physical enhancement needs in a healthy manner.

The second key finding relates to alcohol. Marketers should promote the drawbacks of consuming alcohol for social or enhancement reasons. There is a heightened concern relating to the risk of unsafe behavior, rape or regretted sex under the influence of alcohol, as well as a host of physical health-related problems. Social policy makers also need to point out these concerns. Policy makers should encourage consumption of alternative, healthier, and less risky products in order to meet enhancement and social motivations. They might consider highlighting norms around alcohol consumption. Research has shown that students reduced their alcohol consumption following a social norms marketing campaign, which changed their perceived norms about drinking quantity and frequency [24].

In sum, as the research suggests, the two products I chose contrast in that consumption of one provides long-term happiness and the other does not. It should therefore be the focus of marketers and policy makers to promote the product that has a positive influence on the consumer and to reduce the consumption of those products that harm consumers, in this case, alcohol.

6 Conclusion

In conclusion, the present study aimed to investigate happiness related to consumption of gym membership and alcohol, and the motivations associated with both. Results indicated that firstly, using the gym made individuals happier than drinking alcohol, and secondly, that image, enjoyment, relaxation and physical enhancement were the most common motivations for gym membership, and that social and enhancement were important for alcohol. There were significant age and gender differences in the motivations for using gym membership but not for using alcohol. No significant differences were found with regards to occupation in the motivations for using alcohol or gym membership. Future directions may include investigating the image consumers are aiming to achieve by attending the gym.

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Risk Analysis and Management Mechanism Innovation on Northwest China Urban Minority Floating Population—A Statistic Sample from City of Xi'an

Ze-zhao Liu, Hui-jia Wang, Juan-li Wang, and J. Huang

Abstract As an unique phenomenon in China's rapid industrialization and urbanization, agglomeration of minority floating population into the central cities not only brings positive developments but also associates with risks and vulnerabilities. Management innovation is a core aspect of societal risk mitigation. Regarding that Xi'an City takes the representative of typical significance of the China Northwest Minority floating population, the paper presents constant dilemmas of three long-standing management contradictions in the aspects of current urban minority floating population, and attributes them to city risk source derived from the flowing disturbances and deep obstacles for the urban development, security as well as stability of ethnic relations. Details have been provided on the case representation scheme and management mechanism. The proposed operational methods increase the applicability to many real-world settings, where the liquidity risk mitigation depends on more qualitative management innovations.

Keywords Ethnic floating population • Minority • Public policy • Risk • Xi'an

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1 Introduction

Since the beginning of the twenty-first century, the level of urbanization in China has been undertaking an unprecedented rapid development. According to the statistic report issued by the Chinese Academy of Social Sciences that the proportion of China's urban population will surpass over 50 % in the "Twelfth Five-Year Plan" period [1]. In this historic process of transformation, a special problem emerges upon floating of the minority population. Xi'an, capital city of Shaanxi province in China mainland and the Northwest super-large central metropolitan, has long been attracting a greater number of national mobile populations due to its convenient transportation and regional political, economic and cultural advantages. Survey from the research group point of view indicates, to some extent, that the flow and gathering groups really reinforce multicultural inclusiveness and create a number of unique national circles. However, the flowing of people also brings lots of management pressures over the social order, community construction and even social stability with reality of risk.

Obviously, interpretation of urban influence and social risk causal mechanism for Minority Floating Population cannot be separated from transformation and system changes in the economic and social management positioning. Confluence of ethnic groups in the context of China's rapid social change could be divided into the differentiation of the era upon the central city straddling cross flow from the pursuit of a better life vision, and the reality of the economic status as well as social disadvantaged urban modernization. On the whole, the special group tends to expand the social risks boundary leading certain aspect of resentment and access to trigger "collective protest" [2]. Throughout the city mega-events occurred in recent years, a number of clashes involving floating population of ethnic minorities manifest a notable feature that occupying a larger proportion of the economic benefits generally associates with complex disputes [3]. The spread of "relative deprivation" is an important variable to explain the groups inducing to instability factors.

2 Significance of the Issue Explored

The Northwest part is one of the important regions of ethnic minorities in mainland China, and historically serves as debated hot spot over regional stability Xi'an, the centre metropolitan city with the most influential force as the Northwest Territories, has long been attracting minority population of a large-scale flow of migration. With the accelerating pace of urbanization and urban skeleton & scale widening in recent years of Xi'an, minority floating population trends speed up in the mass spread from the city centre to the outer suburbs, which also brings some new risk impacts to the social order.

We conduct a team survey from February 2011 to March 2012 around the flowing issue. Result indicates certain characteristic for this large group, which could fall into the categories as follows:

2.1 Economic-Type

The main motive for various minority population inflows into Xi'an administrative region is to find sound job and improve the economic situation. Moreover, the livelihood as well as educational development of their generations are the priority for consideration, as become increasingly to occupy a profound agenda. As matter fact, the economic-type population flow acts as a common reality in global context [4].

2.2 Religion-Type

Owing to historical heritage, Xi'an city remained lots of religion sites as well as ethnic spots, of which Muslin groups occupy the most part. The sites attracted annually a large number of Muslin around the districts in congestion for religion causes. Therefore, the traits of religion-motivated manifest an apparent phenomenon for Xi'an. One point worth mentioning is that due to the low quality culture and lack of professional skills, a number of tramps are usually access to low-tech, low-level industry employment with poor physical exertion. Specifically, the Xi'an City Minority Floating Population significantly are inhabited by the form of "*living together*". For instance, *Wai Temple Door* and *Hometown Door Bulk* inhabited by the most prominent feature of the populations reside.

2.3 Performance-Type

Unique cultural practices of ethnic groups and nationality performance showcase have attracted attention in some local governments to expand the local tourism industry and extend economic development with target upon ethnic characteristics attractions in construction and infrastructure planning, as to certain extent also strengthen current tribe gathering.

2.4 Tramp-Type

Minorities flow of national culture and identity of the vast majority of the population in Xi'an mainly rely on centralized focus on specialty industry employment, career choices and breadth of the distribution as well as the underlying such factor intertwined as non-traditional informal sector and the field of Employment Channel. Due to geographical, historical and other priorities, the Xi'an city in Northwest Ethnic Regions enjoy culture, lifestyle wellbeing such as a high level of consistency, which pioneered the minority operating characteristics of roaming tramps.

Accompanied by major changes in China's social structure and national population flow acceleration, the security incidents involving urban ethnic floating staff are constantly on the rise, as manifest a trend of complexity. In addition, people involving mass outbreak of the conflict are also greatly increased social stability maintenance difficulty, which bring a lot of risk variables and realistic challenges to the stable situation in the northwest region. Another concern is that the minority population is increasing year by year to Xi'an, intensified market competition and the interests of obstruction, also the contradictions and disputes within groups are growing. According to our survey, it was found that in recent years due to financial disputes, business conflicts, allocation of injustice and ineffective mediation, Xi'an experienced lots of incidents around conflicts of interests.

3 Management of Long-Standing Abuse and Risk Source

In recent years, urban population floating of the ethnic minorities affiliated with a series of problems caused centre attention by the scholars, and urge hot discussion for the related deep-seated multidimensional risk factors [5, 6]. With our survey of Xi'an, we found that, in addition to economic reasons and external factors, urban social management system for special groups in identifying, accepting and regulation of the disorder are undeserved, as is the important root cause of risk conflicts.

3.1 Administrative Control Mode

The administrative control mode originates from the traditional planned economic model and long-term centralized cultural influence. Social fields in China are infatuated with relatively strong administrative color in order to directly control of the human, financial, material resources. Reviewing the examination and approval as the main way of instrumental control mode are the most thinking pattern in many public departments and officials. In some degree, the same mapping also depicts in national floating population management behavior patterns.

To strengthen the administrative control, manipulating a strong administrative instruction means for population management standard, as are a very typical decree. To promote the subjective color, display and stiff single change, individual standard is property oriented, when applied to multiple complexity and flow in the different ethnic groups inducing mass opposition sexual tension. According to the statistical

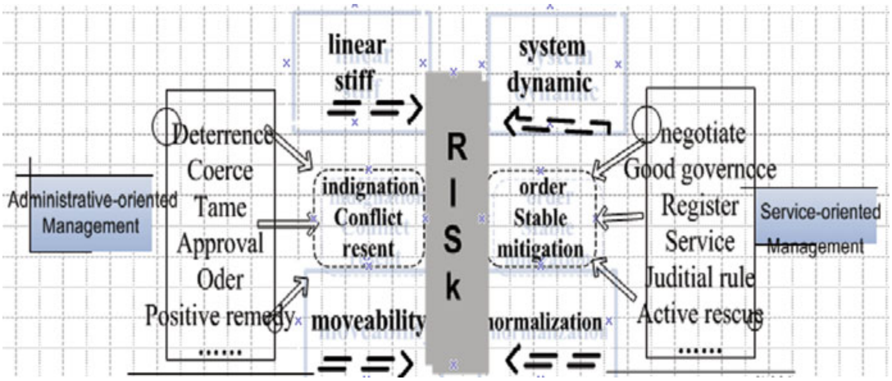

Fig. 1 Governance disparity between administrative-oriented management and service-oriented management

analysis of the official reports, a series of conflict outbreak of Xi'an city in recent years in the people business class have transferred quite partly from initial source to management law enforcement to other personnel arrogance rude, and science program mode is undeserved. Fundamentally, the opposing aspect between administrative-oriented and service-oriented management mode would result in different policy effects (see Fig. 1). Disputes or property upgrade process often have been hidden an "administrative plugging pressure" evolution path.

3.2 Binary System

Conventional Binary system plays a vital position in both traditional rural & urban areas, and management difference of the planned economy is of great influence of thinking. China has long been involved in population management binary segmented system. Rapid economic change, transformation of the economic and social management system reform lags behind in brightly form both propulsion of synchronization, single linear development isolation inspire many social contradictions, and cause public governance risk. "In China, many of the floating population problems are actually made up of China's management system construction focus" [7].

For a long time, the management system of the what is called *household register* (Hukou in Chinese) is given priority to urban citizens, and labor employment, public welfare, social security system, education, health care, housing and other public policies are significant deviation in the town residents and special groups. The issue of the floating population are constructed by all kinds of institutional, management operation level rigid constraint, ethnic floating population in complicated by national character is in weak edge position, and cannot have access to

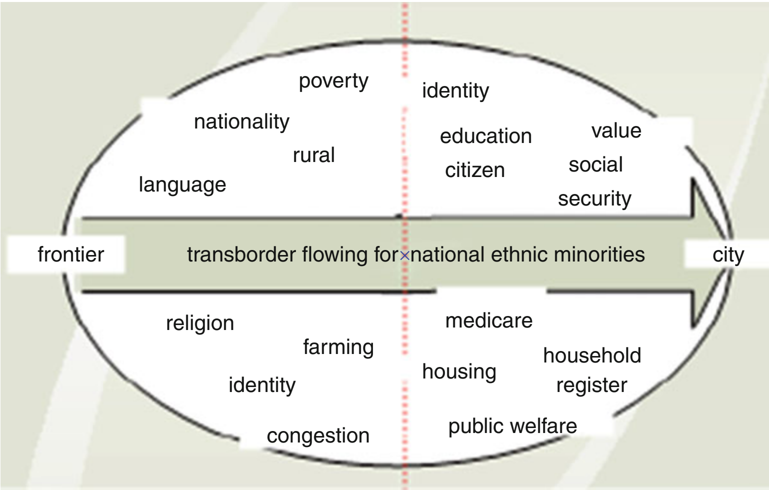

Fig. 2 Identity between rural & urban for ethnic minorities

urban residents or the minority equal rights, encounter a series of "identity lost" and "identity crisis". Just as American sociologist Perkin puts, the establishment of procedures and standards often make the resources and opportunities for some people but reject the other part [3]. On the basis of race, nationality, religion for the standard some social groups are deprived to enjoy resource inside, as is the public policy exclusive reality, China's "one country two policy for rural and urban areas" as the basic characteristics of the "new dual structure" ([8] see Fig. 2) intensifies the real profit distribution, and is so far show no trance of balance. Rapid changes in the external environment and social pressure, the special national "deprived feeling" growth are developing group isolation risk buried hidden trouble, in fact, they caused the unstable factors for transformed system.

3.3 Risk Under the Prejudice

Prejudice is in China's urbanization, industrialization great-leap-forward development process, and the rural floating population initially intend to similar scene. Minority population to more developed region flow is the necessity of the social development phenomenon, rational response and institutionalization for public management department to deal with when conferring responsibility. However, the long-standing floating population prejudice exists in wide scope especially for the northwest minority flow in cultural bias in some sectors and civil servants. To some degree, northwest minority religious factors are of special sensitivity, and small event handling failure would often cause incompatible conflicts. Obviously, prejudice is the discrimination basis for generation, From Xi an National Department we learned that in recent years the casual aspect of what is labelled “do not respect national people” and “discrimination prejudice” as well as such reasons as “the initial incentive or indirectly causing by the contact population floating of the ethnic minorities” occupy the whole group disputes in a certain proportion in the conflicts which ought to inspire enough vigilance by relevant administrative sectors.

4 Innovation of Management Mode and Constructed Coping Measures

The ethnic minority floating population is largely incorporated in urban floating counterpart, which not only occupy common trait but also independent characteristics. Facing the accumulated risks during the floating process, the managing mode is urgently aspiring scientific innovation, which needs to construct service-oriented dynamic mechanism reform in order to elevate the effective level under the context of risk society.

4.1 Linkage and Legal Aid

Reality practice shows that it is difficult to fully cope with population floating of the ethnic minorities’ varied complicated situation and implement public responsibility only by a single national department. Thus it is necessary to establish the authority of the unified leadership, strengthen the coordination of multiple sector linkage as well as the common force. In order to comprehend the city first-line real situation, public security sectors, family planning branches and street/community together with relevant supervising department shall achieve full cooperation. The establishment of population floating of the ethnic minorities should touch bottom conventional mechanism, construction of tracking information database, positive preparation into the city national personnel of electronic archives platform, which could be applied in control information summary analysis. The national religious function mechanism can learn from some domestic advanced regions and international social work experience, and safety defence departments cooperate, in the urban population belt, street community, between urban and rural areas as well as other key location area as a whole to establish “minority people contact” or service station. Relevant management personnel placement field for set service station through the rental housing, work management, sanitation, epidemic prevention, family planning and other special management, dynamic master effective real-time information.

For minority culture carriers & disseminator and the *Han* nationality population are the main body of the city mainstream culture, there is a big gap between the realities for minority groups. Owing that the population own relatively low cultural quality and the modern legal awareness, when encountering individual rights violations or damaged, the group of people often lack the proper legal way to seek support and protection of the initiative, while on the opposite taking collective behaviour, and even extreme actions. Research statistics found that in recent years, ethnic minority floating population in Xi'an, especially the younger generation (commonly known as 1980s, 1990s) manifest legal thinking indifference. Disruptive crime and group conflicts show ascendant trend. In view of this, to promote the minority population legal aid centre/base construction, disseminate method of worship, build a conflict resolving legal disputes are particularly an urgent necessary channels, the purpose of which is targeted for population floating of the ethnic minorities to provide proper legal support convenient channel, reduce cost, and guide the appeal to help with the law to safeguard their own rights.

4.2 Economic Support and Aids

In view of minority groups employment independent feature prominently, administrative sector ought to additionally support national economic development and strive to create the appropriate employments, such as food and beverage industry, technology and culture industry, to construct the cultivation of appropriate national characteristics, living environment of business [9].

On one hand, to build a convenient platform for public service, the government ought to take the lead in promoting the national comprehensive, professional skills courses, training courses, cheap or even free of charge to the floating minority groups for skills to support, enhance their own survival abilities. Also, it is urgent to promote the national "flowing tide to business circle" and acquire, vertical favourable external supporting conditions; On the other hand, in both types of economic support sectors it ought to actively introduce the national poverty alleviation project applied in the floating minority population, relying on a variety of ways to achieve stable employment of migrant workers in city management into public service in the system, supply the town citizen treatment, and publicly set up demonstration, encourage more benign development.

In the northwest region city, national concentration becomes a characteristic of group flow, such as Xi'an City *Hui* floating population is more concentrated within specific areas or regions. Thus government can rely on tourism culture advantage, collaborative Islamic culture energetically develop ethnic cultural tourism resources, promote employment as well as national culture industry together so as to attract more personnel to participate in the national population movement.

4.3 Function of Social Community

Ethnic minority groups sincerely inspire for the identity of individuals seeking confirmation, hug heart with the mainstream Chinese conventional rules. However, significant number of inferior position and historical culture has intensified the individual unique national identity and affinity memory, reality shows a series of national awareness, attitude, behaviour, attribution, pride, are deeply rooted in the cultural gene. Some internal elite knows the spirit of national culture, and can directly or indirectly affect individual survival as well as development directions [10].

Therefore, to deal with any national problems could not ignore the characteristic, minority floating population management should make full use of a unique family, education, rural edge margin network and elite values [11]. Local public management shall actively seize the initiative with its insight into details; pass issued by a convenient path, promoting regional civilian appointment. Religious Bureau and national associations, organizations might build the masses of organic connection, build city of minority floating population management of the "second ground". In Xi'an city, for instance, through the Association for the Advancement of National Unity (AANU), minority enjoy a certain prestige, political consciousness and high representative personage as head and coordinator, to the various districts and counties to form unit under the point of contact. People of minority nationalities and enterprises, social organizations of communication medium, reflect the groups' mobile voice, increase special demand and timely dredging solutions to minimize conflicts, assemble feedback on failure risk conduction hazards.

In addition, the public functions related can fully rely on the Minority Floating Population Agglomeration community, residence, work areas, and push city folk groups forward as well as religious organizations in education, probation, assistance and other areas of potential influence. National behaviour constraints guiding force of traditional customs and religious teachings in the city community management continue to play a major role, guide its positive effect, to reduce its negative extreme levels, prevention and abatement of minority floating population crime and violence of the national cause.

4.4 Equal Attention from Prevention and Deterrence

Education, counselling, support functions, as a national public policy mainstream way in the city of minority floating population, management system must adhere to and be fully extended. Practice shows that this way to resolve conflicts, reduce systemic risk has special significant value, and the results are remarkable. At the same time, extreme environment rigid deterrence is also an indispensable tool that must also be kept using.

In view of the floating population of ethnic minorities in a handful of deliberately ethnic disputes, undermining national situation, challenge events, interference with social stability of the criminals and public security, department shall uphold the rule of basic law principle rationally and strongly. The section ought to accurately strike flexible initiative tactics, dissolve human risk derivative barrier, to create a stable and orderly public security environment. Some incidents do not cover up, nor expand rapidly to massive territories without delay, careful, and fair reasonable processing. All these dimensions are supposed to be strengthened and need prudent supervision.

5 Discussion and Limitation

Since predicting group behavior and living transformation of ethnic minority remains a large challenge, especially under the context of multi-mixed complex context in China. A number of objective factors coming from ethnic and religious side can act as analysis barriers. Our study only examined a subset of minority groups as China Northwest origin and does not preclude the possible transformation of other unmeasured groups; for China is such a large multi-ethnic nation that one region could not depict the whole pan sphere in the nation. Thus our discussion and conclusion originate lots of restrictions in analyzing ethnic minority problem in China such as data collection, individual and institutional factors. Specially, data coming from Xi'an city is limited to interpret other minority group of people in China mainland, and expand the data source could be one vital directions in relevant analysis.

Future longitudinal research, we believe, might incur upon analyzing the dynamic relationships between ethnic minorities and local nationalities embedded in social-contextual predictors, and exchanges among different ethnic minority groups still serve as a challenging issue. Moreover, a greater number of valid variables or influencing factors in future research would be added for an evaluation of the theoretic model with more sophisticated multivariate techniques, such as structural equation modeling.

6 Conclusion

Compared with the general flow of mainstream population, minority flow is a not just reflection of the urban and rural area, but also the national communication. Therefore, ethnic floating population's social integration also manifests more traits of complex and suffering. Stricted by our country's urban and rural differences and ethnic disparity, divided common, ethnic floating population is increasingly becoming one of the typical vulnerable groups in urban society. In a sense, ethnic floating population's social integration degree of discretion is to measure the difference between urban and rural areas in our country. Ethnic floating population in urban work life is a continuation of their socialization process; the urban social integration is actually a dual economic structure, the dual society structure, dual psychological structure of digestion process step by step. The improvement of urban social integration degree often means that its modernization, urbanization, and urbanization level enhances increasingly.

It conforms to the interests of floating population and the city by their mutual respective to promote ethnic floating population into the urban society as soon as possible, Governments must take responsibility and develop specific policies, vigorously build for fusion center for social policy system, at the same time, promote social inclusion, social justice and social equality by exhibiting city economy, strengthening construction of the national community.

Facts have proven that if administrative tools for ethnic minority group are in excessive application, it is more likely to lead to management dilemma and social discrimination, thus gradually pull social resent and psychological distance between ethnic minorities and the urban residents. Therefore, only by management innovation performed and management system support, can we ensure the avoidance of ethnic segregation and isolation of risk even for public policy making and social stability assessment.

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The Influence of Enterprise Network Capability on Technology Innovation—Moderating Role of Learning Orientation

Xiao-qin Zhu and Lu Ma

Abstract In this paper, learning orientation as moderating variable is introduced into the study of the relationship between the enterprise network capability and the technology innovation; the sample of enterprise in Guangxi is extracted as the research objects; the influence of enterprise network capability on technology innovation is explored under different levels of learning orientation. The results find that the network capability of enterprise has a significantly positive impact on the technology innovation. Relative to a low level learning orientation, a high one can promote the better influence of enterprise network capability on technology innovation, and plays a more conducive role to technology innovation. The learning orientation plays a positive regulatory role in the relationship between the network capability and the technology innovation.

Keywords Knowledge • Learning orientation • Network capability • Technology innovation

1 Introduction

With the increase of the globalization of markets, the difficulties and risks of innovation, the modes of enterprise innovation are gradually shifting from being closed to open. To make the innovation no longer a simple atom type process but an interactive cooperation process, having a positive cooperation with external research institutions, universities institutes, competitors and so on is needed. Enterprises need to integrate the various resources of network partners to improve the success rate of innovation (Bougrain and Haudeville 2002) [1]. So dynamically obtaining

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and integrating inter-organization knowledge through network relationships and locations will be another way for enterprises' successful innovation. Therefore, the network capability of establishing, managing, and moderating important external relation has become core resources for enterprises. An enterprise with strong network capability can put itself in the network centre and can act as a strategic player, which not only will make itself available to the information flow of external organizations, but also can effectively choose its future partners (Wasserman and Faust 1994) [2]. At present, although scholars, home and abroad, have had empirical researches on the relationships between the enterprise's network capabilities and innovation, there is less attention to under what conditions can the network capabilities be more conducive to the enhancement of innovation. Zahra and George [3] stressed the importance of external knowledge sources in enterprises, but the validity and strength of searching knowledge often depend on the organization's learning desire that can affect the acquisition, explanation, evaluation and embrace or discard of information (Argyris and Schton 1978; Simonin 2004) [4, 5], that is to collect what kinds of information, how to interpret them, and how to evaluate and share the information affected by learning orientation. Therefore, this article explores that under different levels of learning orientation, the network capabilities of enterprise how to as well as the extent to influence the technology innovation.

2 Theoretical Assumption

With innovation is becoming increasingly complex, the competitiveness of enterprise more lies on the ability to obtain and generate new knowledge. In the real production and operation, the truly successful innovation to acquire and integrate knowledge is often made through the interactions and cooperation with other organizations and external environments. Even making an innovation within an enterprise needs to understand the demands of the market and the latest technologies. Therefore, the composition and organization of the enterprise network have largely impacted on the ways and the effects of enterprise innovation. Ritter (1999) survey [6], German medium-sized enterprises as the research object, discussed the influences on the innovation of products and processes by the network capability of enterprise, it found that there was a significantly positive correlation between them. Ritter and Gemünden (2003) considered that there was an evidently positive relationship between the existing network capabilities and technical capabilities by empirical tests, and with network capabilities, companies can participate in the processes of other enterprises' technology development [7]. Ting and Chiu [8] verified that network capabilities and network status had a positive impact on the cluster enterprises innovation performance. Basing on all above, we propose the following assumptions:

H1: The network capability of enterprise has a significantly positive impact on technology innovation.

Learning orientation is a series of organizational values that can influenced the enterprise tendencies of creating and using knowledge (Rhee et al. 2010) [9]. Organizational learning theory suggests that the lack of learning orientations hinder the enterprise to develop learning cognitive impairment. Learning orientation affect the acquisition, interpretation, evaluation, embrace or discard of information (Calantone et al. 2002) [10], that is to collect what kinds of information, how to interpret them, and how to evaluate and share the information affected by learning orientation. In the short term, the growth of learning orientation will have a direct impact on the quantity and quality of the processing market (the generation and dissemination of information). Through the indirect processes of the market information, improving enterprises' ability to acquire and use the quantity and quality of knowledge by building platform with network capability becomes available. In the long term, learning orientation growth will improve the quality of information interpretation and organizational memory function, and by improving the market information processing behavior, indirectly promote the organizations to search knowledge better with the help of external network relationship. Witt [11] hold that technology innovation and new knowledge were inseparable, and regarded the innovation process as a process of the generating new knowledge. Zhao-quan Jian et al. [12] believed that the innovation activities was a process of an input of knowledge and then an output of it. Therefore, we propose the following assumptions:

H2: Compared with a low tendency of learning orientation level, a high one can enhance the influence degree of enterprise network capability on technology innovation.

3 Methodology

3.1 Sample Collection and Description

This article mainly focuses on enterprises, which involves the data of network capability and learning orientation that can not be obtained directly from the publicly information, so questionnaires for data collection is used. In order to ensure a smooth research and improve the recovery rate and effectiveness of the questionnaires, Guangxi region is targeted as the research area and the questionnaires are distributed by e-mail, mail and in persons. There are 255 copies of the questionnaires in total, and with 173 copies recovered, the recovery rate is 67.8 %. After excluding the invalid questionnaires, 156 copies are remained. The sample enterprises are classified according to their ages, staff volume and asset sizes, which are shown in Table 1.

From the viewpoint of age, there are 9 enterprises with less than 3 years, 5.7 % of the total; 43 enterprises established for 4–6 years, 27.5 % of the total; 46 enterprises

Table 1 Basic information of the sample enterprises'

Age	Percent (%)	Amount of staff	Percent (%)	Assets size (million)	Percent (%)
≤3	5.7	≤300	9.4	≤5	5.5
4–6	27.5	301–1,000	72.1	5–50	54.6
7–10	29.4	1,001–2,000	11.9	50–100	27.3
11–20	27.8	2,001–5,000	4.3	100–300	11.4
≥20	9.6	≥5,000	2.3	≥300	1.2

established for 7–10 years, 29.4 % of the total; 43 enterprises established for 11–20 years, 27.8 % of the total; and only 15 enterprises with more than 20 years, 9.6 % of the total.

From the viewpoint of staff volume, there are 15 enterprises with less than 300 staff, 9.4 % of the total; 112 enterprises with 301–1,000 staff, 72.1 % of the total; 19 enterprises with 1,001–2,000 staff, 11.9 % of the total; 7 enterprises with 2,001–5,000 staff, 7 % of the total; 3 enterprises with more than 5,000 staff, 2.3 % of the total.

From the viewpoint of asset sizes, there are 8 enterprises with an asset of less than five million RMB, 5.5 % of the total; 85 enterprises with 5–50 million RMB, 54.6 % of the total; 43 enterprises with 50–100 million RMB, 27.3 % of the total; 18 enterprises with 100–300 million RMB, 11.4 % of the total; 2 enterprise with more than 300 million, 1.2 % of the total.

3.2 Data Description

In this study, software SPSS17.0 is used for processing the data and analyzing the standard deviation, skewness, kurtosis, etc. of the items in the questionnaires. Kline [13] proposed that when the absolute value of the skewness was less than 3 and the kurtosis absolute value was less than 10, it indicated that the sample basically follow a normal distribution. The statistical results shows that the absolute value of the skewness of items in the questionnaires is less than 2 and the absolute value of the kurtosis is less than 3, which indicates that the figure of each item basically follow a normal distribution, and an confirmatory analysis can be made.

3.3 The Analysis of the Reliability and Validity

Reliability is used to measure the measurement error degree that involves the estimation of a measurement method not influenced by randomness and instability [14], and only a higher reliability can ensure the consistency and stability of the measurement effect. Validity refers to the degree that by using measurement tools, researchers can properly measure the questions they want, which can be divided into content validity, construct validity and criterion validity. In this paper, foreign maturity scales are adopted. The scales developed by Walter and other researchers [15] are employed in network capability, including 19 items: "collaborative arrangements" (6), "relationship skills" (4), "knowing partners' information" (4), "Internal communication skills" (5). The scales made by Sinkula and other researchers [16] are used in learning-orientation, containing 11 items in total: "commitment to learning"(4), "shared visions" (4), "open mind" (3). And the scales proposed by Ritter and Gemünden (2003) in technological innovation are put to use with six items in total: "product innovation" (3) and "process innovation" (3). Since all the Cronbach's figures in scales are more than 0.7 and the load figures of each item are above 0.6, the questionnaire has good reliability and a high validity.

4 Empirical Analysis Results

4.1 Variable Correlation Test

In order to simplify the process of operational analysis, enterprises network capabilities, learning orientation and technology innovation variable are simplified (taking the mean value of all items in the variable as the value of the variable) in the thesis. Since these variables have a good reliability and a high validity degree, it is possible to meet the single processing requirements. According to a correlation analysis, the correlation coefficient between the variables is shown in Table 2. As it shows in the Table 2, there exists a significantly positive relationship between network capacity, learning orientation and technology innovation, which also serves to the detection by regulating effects.

Table 2 Variables descriptive statistics and correlation coefficient matrix

	1	2	3	4	5
Age	–				
Staff volume	0.350**	–			
Network capabilities	0.129	0.199*	–		
Learning orientation	0.028	0.047	0.417**	–	
Technology innovation	−0.025	0.073	0.494**	0.574**	–

Indicate: *$p<0.05$; **$p<0.01$; N = 156

Table 3 The results of the regulatory effect tests

Variables	Value
Age	−0.06
Staff volume	0.07
∆F	0.63
R^2	0.01
Network capabilities	0.37**
Learning orientation	0.38**
∆F	26.6
R^2	0.41
Network capabilities and learning orientation	0.16**
∆F	30.4
R^2	0.37
ΔR^2	0.36

Indicate: $^{**}p<0.\ 01$; N = 156

4.2 Regulatory Effect Tests

During process of the regulatory effect tests, firstly, the control variables are introduced to the regression of the outcome variables, the independent variables follows, regulation variables are reintroduced, and finally the interaction terms of the independent variables and regulated variables are introduced. The operation results are shown in Table 3.

From Table 3, the control variables do not significantly affect the enterprise's technology innovation while independent variables, network capability, for technology innovation have a evidently positive impact (0.37**) on technology innovation, hypothesis 1 being verified. Moderating variables, learning orientation, also have a remarkably positive impact (0.38**) on technology innovation, the interactions of network capability and learning orientation make an observably positive impact (0.16**) on technology innovation, which proves that the functions of learning orientation between network capability and technology innovation get supports, assumption 2 being verified.

5 Conclusion

In this paper, on the basis of previous studies and taking Guangxi enterprises as the research objects, we further analysis of the influence of enterprise network capability on technology innovation, verifying that the network capabilities have a significantly positive impact on technology innovation. Meanwhile, we find that learning orientation plays an important role in the regulation of the relationship of the network capability and technology innovation. From a theoretical sense, basing on the contingency perspective, this study finds that the influence of enterprise network capability on technology innovation will be different in different situations. With strong learning orientation, an enterprise can greatly improve its level of innovation. Otherwise, an enterprise's improvement will be limited. From a practical sense, the present enterprises' innovation has become interactive. To improve the chances of success while reducing the risk of innovation, enterprises need to maintain good cooperative relations with suppliers, customers, banks and even the government, the media and competitors to build their own innovation networks to obtain innovative resources. At the same time, enterprises need to take organizational learning as the basic value, and integrate it into the corporate cultures. Also, enterprises need to spread and share the internal learning vision to form an interior consensus on Organizational learning and make the whole enterprises full of a studious spirit.

6 Discussion

In this study, there are still many inadequacies. First of all, due to the difficulties of data collection, all the data is collected in the same period and the cross-sectional data are not enough to confirm the causal relationship between the variables. The follow-up study analysis can try using a longitudinal research design; Secondly, the study selected the Guangxi enterprises as the research object, not covering the enterprises of other provinces, and meanwhile, although the number of samples reaches the demands of the statistical analysis, there is no distinction of the sample enterprises in industry and class. The follow-up study will select a wider area and make a comparative analysis by classifying the samples.

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Relationship Among New CEO's Characteristics, TMT Adjustment and Performance—Empirical Study Based on ST Listed Enterprises

Wei-ning Li and Yi-ning Zhang

Abstract Based on Upper Echelons Perspective, this study focuses on key problems from previous researches on CEO succession, to analyze relationship among ST listed enterprises' new CEO characteristics, TMT adjustment and enterprise performance changes. We choose 108 CEO succession samples from listed enterprises which replaced CEO from 2000 to 2009, then find that new CEO age and education level have significant positive effects on enterprise short-term performance changes. New CEO without working experience as CEO can better improve short-term performance than the CEO with relevant experience. New CEO generated internally can better improve long-term performance than CEO generated externally. TMT adjustment has a significant positive effect on short-term performance changes, but new CEO's characteristics have no significant effect on TMT adjustment. This study provides a new perspective for researches about transformation strategy of performance declined enterprises, and also provides a basis for Chinese enterprises to select and replace CEO.

Keywords CEO characteristics • Enterprise performance changes • ST listed enterprises • Top management team adjustment

1 Introduction

Upper Echelons Perspective [1] emphasized the importance of top management team (TMT) when TMT drove enterprise strategic transformation [1], especially the function of CEO [2]. When enterprise performance declines, the board of directors often changes CEO to implement strategic transformation to improve enterprise

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performance. But there remain large differences among the results of different enterprises' strategic transformation [3]. Transformation strategic decisions of performance-declined enterprises are collective decisions dominated by CEO; these decisions are also the results of interactions between CEO and TMT. After taking office, whether the new CEO can get the TMT's trust and support is the key to strategic transformation's success. The strategic transformation of performance-declined enterprise is filled with difficulties and risks, it will meet unexpected resistances at any time [4, 5][1]). Some of these resistances are from outside, some from inside, but most of them come from enterprises' original conventions and staffs. When implementing strategic transformations, changing and adjusting the original management team is a measure to overcome the inertia and resistance from inside.

Among the listed enterprises titled with ST (Special Treatment) from 2000 to 2009, more than 40 % of them replaced their CEOs. So the research about the effects of ST listed enterprises' new CEO characteristics and TMT adjustment on performance will provide a new perspective for the strategic transformation in Chinese situation, and will provide the basis for Chinese enterprises to choose and change CEO, in that way to improve Chinese manager market.

2 Theoretical Basis and Assumptions

When the enterprises performance continues to decline, the board of directors chooses new CEO to promote the strategic transformation [6–8]. CEOs are the highest administrative personnel employed by the board of directors, they control and command the relevant resources to realize the goal of enterprises, they also play important role in strategic adjustment process [9]. CEO characteristics affect enterprise performance [10]. Their age, education background, professional background and working experience influence enterprise choices about transformation strategy.

2.1 The Effect of ST Listed Enterprises' New CEO Characteristics on Enterprise Performance Changes

Young CEOs who are full of energy dare to take risks, to innovate and to develop new markets. But as the growth of the age, their preference for risk, the degree of acceptance to new things and the capacity of processing information will gradually decline. In China, CEO's social relation network plays a key role in acquiring scarce

[1]The national nature science foundation of China: Research about the effects of CEO characteristic and TMT heterogeneity on transformation strategy and performance in the performance declined enterprises (No. 71172073).

resources. In face of the ST listed enterprises' performance decline, older CEO can reasonable deal with the relationship among government, society, customers, media and other related interest groups, they are more likely to get scarce resources in order to promote enterprise development. Therefore, we propose the following hypothesis:

H1a: The age of ST listed enterprise's CEO has significant positive effects on the enterprise's short-term and long-term performance changes.

TMT's education level is closely related to their information processing ability and managerial flexibility; it also has a significant positive effect on the enterprise performance [1]. The higher the TMT's education level is, the more effective information TMT can get, and the CEO's with high education level will also improve the efficiency for the enterprises to collect strategic resources. The wealth effect of CEO succession has a significantly positive relationship with new CEO's education level. So we propose the following hypothesis:

H1b: The education level of ST listed enterprise's CEO has a significant positive effect on the enterprise's short-term and long-term performance changes.

According to Upper Echelons Perspective, CEOs usually put their own experience from original profession on the new job. If new CEO has working experience as CEO, they will make decisions more effectively, but the experience may also make them stubborn and narrow minded. ST listed enterprises face delisting risks, so that their CEOs need to break the old management mode urgently and reform operation methods in order to improve performance. New CEO without working experience as CEO has more courage to reform. So we propose the following hypothesis:

H1c: For ST listed enterprise which has new CEO without working experience as other enterprises' CEO, its short-term and long-term performance will be significantly better than the enterprise which has new CEO with relevant experience.

Seventy percent of the domestic enterprises' new CEOs generated internally since 1995, and 68 % of the current CEOs generated internally. Enterprises whose operating performances are declining continually may endure more pressure from internal and external interest groups, and their operation conditions are more complex. CEOs generated internally are more familiar with enterprise operation, thus they can better allocate resources to help enterprises out of trouble. So we put forward the following hypothesis:

H1d: The ST listed enterprise which has new CEO generated internally will have significantly better short-term and long-term performance than the enterprise which has new CEO generated externally

2.2 The Effect of ST Listed Enterprise's New CEO Characteristics on TMT Adjustment

After CEO succession, the characteristics of new CEO will have significant effects on TMT adjustment. The stability of TMT is very important to enterprise normal operations, and it can ultimately affect the enterprise performance [11]. Seniority is a very important asset in Chinese enterprises. As the power distance is large in China, the CEO, who is in the core power position of enterprise, has the right to select and appoint other executives. When promoting the formulation and implementation of transformation strategy, older new CEO tends to eliminate executives who are appointed by former CEO and hold negative attitude on them. The older CEO will also introduce his new management team to make the newly composed TMT to better implement transformation strategy as requested. So we propose the following hypothesis:

H2a: For ST listed enterprise, the order new CEO is more inclined to adjust TMT than younger new CEO

Education level represents a person's cognitive level and way of thinking, the CEO with higher education level will have more systematic thinking to manage the enterprise, they always tend to get rid of TMT members who can't adapt to enterprise development, and who he thinks are lack of the ability of adapting coming strategic transformation. So we propose the following hypothesis:

H2b: For ST listed enterprise, the new CEO with higher education level is more inclined to adjust TMT than new CEO with lower education level

New CEO with working experience as other enterprises' CEO can better understand special human capital. In consideration of stability and efficiency, they tend to keep the integrity of TMT to ensure the stability. The theory about special human capital shows that after mutual break-in, TMT members can produce a special kind of productivity called co-operation, besides tacit cooperation. For new CEO without relevant experience, they will have more reform awareness when dealing with personnel assignment problems. So we propose the following hypothesis:

H2c: For ST listed enterprise, the new CEO without working experience as other enterprises' CEO is more inclined to adjust TMT than new CEO with relevant experience

Comparing to CEO generated externally, the new CEO generated internally know more about the problems of enterprise management, they are more familiar with business situation and systems, which drives the formulation of special human capital [12]. This kind of special human capital is gradually accumulated through long-term cooperation between owners and operators, and the longer the time of cooperation is, the more special human capital are accumulated [13]. New CEO generated externally will take more time and cost to form this special human capital. In face of the unfamiliar environment, they need help from enterprise's internal members who are acquainted with enterprise operation. They also must deal with the relationship with authoritative team members as soon as possible, so they won't easily change the organizational structure. The new CEOs generated internally have their own interest group in the original TMT, so they tend to fire the team members that are against to their own interest group. So we propose the following hypothesis:

H2d: For ST listed enterprise, the new CEO generated internally is more inclined to adjust TMT than new CEO generated externally.

2.3 The Effect of ST Listed Enterprises' TMT Adjustment on Enterprise Performance Changes

Numerous studies show that CEO succession is often accompanied by the enterprise strategic transformation and organizational transformation [14]. According to Upper Echelons Perspective, the formation of enterprise strategy depends on the entire TMT rather than a CEO, so it is generally believed that TMT restructuring will help enterprise performance improvement. By analyzing the data of Dutch football league in 1986–2004, Weel (2011) found that there was no statistically significant positive effect of managers' turnover rate on enterprise performance, but he find weak positive correlation between these two variables when he focus on listed enterprises [15]. George et al's study found that, when the enterprise's performance declines, the TMT adjustment would increase performance significantly. So we propose the following hypothesis:

H3: For ST listed enterprise, TMT adjustment has a significant positive effect on enterprise short-term and long-term performance changes.

3 Research Design

3.1 Measurement of Variables

1. Enterprise performance changes: This study not only use ROA's changes that most scholars used to measure short-term performance changes, but also use Tobin's Q's changes to measure the enterprises' ability of value development, in order to concern more about long-term performance changes. This study selects samples from a variety of industries, so we eliminate interferences from different industries on performances as far as possible

$$ROA = (ROA_2 + ROA_1)/2 - ROA_{-1} \quad Tobin's\ Q = \left(Tobin's\ Q_2 + Tobin's\ Q_1\right)/2 - Tobin's\ Q_{-1}$$

$$ROA_i = ROA_{Ci} - ROAQ_{Ii} \quad Tobin's\ Q_i = Tobin's\ Q_{Ci} - Tobin's\ Q_{Ii}$$

i=2,1,−1, Respectively represent 2 years after the CEO succession, 1 year after the CEO succession and 1 year before the CEO succession. C,I, represent company and industry.

2. *The characteristics of the new CEO*: Based on Upper Echelons Perspective, the study selects new CEO age, education level, working experience as CEO and succession source as the variables about new CEO characteristics. New CEO age is the age of new CEO when he (or she) succeeds, which is the difference between succession year and year of birth. Using CSMAR database for reference, this study divides CEO education level into technical school education or below, junior college degree, bachelor degree, master degree, doctoral degree or above, the assignments are 1–5. New CEO, who has working experience as chairman or general manager is assigned to 1, otherwise is assigned to 0. New CEO who is generated internally is assigned to 1, otherwise is assigned to 0.
3. *Top Management Team adjustment*: By adjusting the definition of TMT on the base of CSRC, TMT includes chairman (deputy chairman), general manager (vice-general manager), president (vice-president), director, board secretary, chief inspector, chief engineer, chief accountant, chief auditor, etc in this study. We use the formula of TMT adjustment (SEturn). SEturn = Numbers of executives who leave office 2 years after CEO turnover/Numbers of TMT a year before CEO turnover.
4. *Control Variable*: This study uses the methods from some foreign scholars' studies [16, 17], taking firm size and firm age as control variables. Firm size is measured by enterprise's total assets [18]. Firm age is measured by the number which is the difference between the years of CEO succession minus the year enterprise established.

3.2 Samples and Data Collection

Our research samples have the following requirements. (1) They're Shanghai and Shenzhen listed enterprises and they had been implemented special treatment (ST) between 2000 and 2009. (2) Those enterprises replaced their CEOs (both the chairmen and the general managers) during the ST period. (3) They didn't replace their CEOs again in 2 years after CEO turnover. The characteristic data of new CEOs mainly come from the corporate governance data in CSMAR. The data of enterprise performance mainly come from the financial data in Juyuan Database, while the data of TMT adjustment mainly come from annual reports of those listed enterprises.

4 Research Results

4.1 Descriptive Statistics and Correlation Analysis

From the descriptive statistics, we find that new CEO's average age is 44.74; their average education level is 3.23. In the 108 samples, there are 83 new CEOs have working experience as CEO in the past, 34 new CEOs generated internally, internal succession rate is 31.5 %. This study use SPSS17.0 to do Pearson Correlation Analysis. We find that new CEO's education level and TMT adjustment rate have significant positive relationship with short-term enterprise performance changes (correlation coefficients are 0.253 and 0.212), working experience as CEO have significant negative relationship with short-term enterprise performance changes (correlation coefficient is −0.241).

4.2 Hypothesis Test and the Results

4.2.1 The Effect of ST Listed Enterprises' New CEO Characteristics on Performance Changes

In order to analyze the different age groups, different education levels, different working experience and different succession sources' effects on enterprise performance changes, we analyze variance of new CEO characteristics on performance. Results show that there's no significant differences of long-term performance among different ST listed enterprise's new CEO characteristics. There are also no significant differences of short-term performance changes among different succession ages groups and succession sources. There are significant differences of short-term performance changes among different education levels and different working experience. Hypothesis test and the results are shown in Table 1, F values in Model2 and Model4 are 3.007 and 2.327, which demonstrate the regression equations are significant. New CEO age and education level both have significant positive effects on short-term performance (ROA) changes, meanwhile, they don't have effects on long-term performance (Tobin's Q) changes which indicate H1a and H1b are partly supported. New CEO without working experience as CEO, has significant positive effects on improving short-term performance (ROA), but not on improving long-term performance (Tobin's Q), so H1c is partly supported. CEO generated internally has a significant positive effect on improving long-term performance (ROA), but not on improving short-term performance (Tobin's Q), so H1d is partly supported too.

The variance analysis and regression analysis above show that, ST listed enterprises' new CEO's age and education level have significant positive effects on short-term performance changes. ST listed enterprises, which face continuous performance decline, get a lot of pressure from inside and outside. Under this

Table 1 The effect of new CEO characteristics on performance changes

	ROA changes		Tobin's Q changes	
Variable	Model 1	Model 2	Model 3	Model 4
Firm size(LN)	−0.011	−0.071	−0.282**	−0.316**
Firm age	−0.040	−0.044	0.041	0.013
New CEO age		0.175+		−0.164
Education level		0.288**		0.038
Working experience as CEO		−0.249*		0.090
Succession source		0.022		0.190+
R^2	0.002	0.152	0.081	0.121
Adjusted R2	−0.017	0.101	0.063	0.069
F-value	0.093	3.007**	4.616*	2.327*

+*p*<0.1; **p*<0.05; ***p*<0.01

circumstances, new CEO, who is older and with higher education level, will have better social relationship networks, more knowledge and better decision-making skills to make the enterprise quickly get scarcity resources, adapt to the dynamic and complex business environment, and to improve enterprise performance in the short term.

For ST listed enterprise which has new CEO without working experience as other enterprises' CEO, its short-term performance will be significantly better than the enterprise which has new CEO with relevant experience. In face of delisting risk, CEO without working experience as other enterprises' CEO has more courage to break the original business models and to transform strategy. We find there is no effect of succession source on improving short-term performance, however, new CEO generated internally can better improve long-term performance than CEO generated externally. Compared with other enterprises, ST listed enterprises' internal situation is more complex, new CEOs promoted internally know more about the enterprise operation problems, so they can allocate corporate resources better to make enterprises out of trouble.

4.2.2 The Effect of ST Listed Enterprises' New CEO Characteristics on TMT Adjustment

By analyzing variance, we find except the CEO age, other new CEO's characteristics don't affect TMT adjustment significantly. Regression results in Table 2 show that, the significant coefficients of independent variables are all greater than 0.1, so ST listed enterprises' new CEO characteristics don't affect the TMT adjustment significantly. Therefore the hypothesis H2 is not supported. Because in order to improve performance as soon as possible, new CEO with different characteristics all have to adjust top management team according to the new strategy. ST listed enterprises' TMT adjustments may be affected by strategic adjustment, but not the TMT adjustment.

Table 2 The effect of new CEO characteristics on TMT adjustment

	TMT adjustment	
Variable	Model 1	Model 2
Firm size (LN)	0.079	0.060
Firm age	0.114	0.106
New CEO age		0.072
Education level		−0.017
Working experience as CEO		−0.028
Succession source		0.054
R2	0.020	0.031
Adjusted R2	0.001	−0.026
F-value	1.050	0.541

Table 3 The effect of TMT adjustment on performance changes

	ROA (%) changes		Tobin's Q changes	
Variable	Model 1	Model 2	Model 3	Model 4
Firm size (LN)	−0.011	−0.029	−0.282**	−0.287**
Firm age	−0.040	−0.066	0.041	0.034
TMT adjustment rate		0.222*		0.058
R^2	0.002	0.050	0.081	0.084
Adjusted R2	−0.017	0.023	0.063	0.058
F-value	0.093	1.928+	4.616*	3.182*

+p<0.1; *p<0.05; **p<0.01; ***p<0.001

4.2.3 The Effect of TMT Adjustment on Performance Changes

Table 3 shows that there is significant positive effect of ST listed enterprises' TMT adjustment on short-term performance changes, which is consistent with the results of other scholars' researches [15]. TMT adjustment is a part of the transformation strategy. By TMT adjustment, CEO can fire staffs with low efficiency, choose managers who can better adapt to enterprise strategy, to promote the efficiency and accuracy of the strategic decision-making, and finally improve enterprise performance. For ST listed enterprises, therefore, TMT adjustment can promote the implementation of strategic transformation in order to improve enterprise performance.

5 Conclusion and Insufficiency

Based on the Upper Echelons Perspective and CEO succession samples from the listed enterprises which have CEO succession incidents in their special treatment period, our study analyzes the relationship among ST listed enterprises' new CEO characteristics, TMT adjustment and enterprise performance changes. The main research conclusions are as follows.

1. New CEOs with different characteristics affect long-term performance and short-term performance differently. New CEO succession age and education level have significant positive effects on the enterprise short-term performance changes. And when enterprise which has new CEO without working experience as other enterprises' CEO, its short-term performance will be significantly better than the enterprise which has new CEO with relevant working experience. Internal succession has significantly positive effect on performance changes. These are in line with the results of some empirical studies, but different from others [19]. When enterprise performance declines, the board of directors often changes CEO to implement strategy transformation to improve enterprise performance. When choosing successor, enterprises consider more about their CEOs and the TMT's effects on improving enterprises' short-term performance, while less focus on enterprise long-term value growth. It is beneficial to improve performance and to get rid of the ST list rapidly, but when choosing new CEO, the enterprise should consider more about long-term development and focus more on the relationship between CEO's characteristics and long-term performance. For ST listed enterprises, CEO who has characteristics like higher education level, rich social network resources, working experience as CEO, internal succession should be chosen to improve enterprise performance.
2. For ST listed enterprises, adjusting TMT can improve short-term performance significantly, but it can't effect the improvement of long-term performance. According to Upper Echelons Perspective, we know that the formulation of enterprise strategy depends on the whole top management team. The chaotic and rigid management system is the main reason of ST listed enterprise's performance decline. By adjusting the top management team, firing staff with low efficiency and overcoming the enterprise existing conventions and resistances from executives, enterprises can have the best personnel allocation and the optimal efficiency to improve performance.

Choosing ST listed enterprise as the research object, this study provides a new perspective for the researches about transformation strategy of performance-declined enterprises and also provides a basis for Chinese enterprises to select and replace the CEO. However, due to some problems of selecting samples and measuring variables, there are still limitations in this study. These insufficiencies and limitations are emphasis and difficulties in the following researches. Firstly, the sample size is relatively small. Secondly, new CEO make an influence on enterprise performance by a range of factors, such as adjusting strategy, changing organization and personnel, inputting key resources etc, but among all these factors, we only choose TMT adjustment to analyze in this study. In addition, we don't strictly distinguish chairman and general manager, they are all referred to as CEO in this study. But in Chinese company, chairman and general manager play different roles in deciding and implementing enterprise strategic transformation.

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Research on Collaborative Management Mode of Engineering Cost Based on BIM Technology in Construction Stage

Jin-feng Zhang and Dong-mei Feng

Abstract This paper discusses the relationship of engineering cost, collaborative management mode and BIM technology: Engineering cost management needs to be promoted by collaborative management mode, collaborative management requires BIM technology as a service platform, and BIM technology has been in service for engineering cost, so the three are regarded as complementary relationship. Analyze the engineering cost management in construction stage, and find that it only actualizes the value of engineering cost, and does not add the value of management. Therefore, the paper proposes to establish the mode of engineering cost collaborative management based on BIM technology in construction stage. The new management mode defines the roles of project participants and their functions, requires project manager to establish the mechanisms of collaborative management to mobilize all participants to actualize value-added management. And analyze that the management mode can achieve four targets.

Keywords BIM technology • Collaborative management • Construction stage • Engineering cost • Management mode

1 Introduction

The most prominent theme of the era of knowledge economy is the highly developed information technology and the scientific and technical innovation which gives priority to knowledge industry. Companies have entered the new stage of adjusting

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structure, optimized configuration, and innovative technology and management [1]. Over the years, the development of the engineering cost is adjusted in valuation mode, and did not put forward innovation on management mode, has no substantial change of management. And the current management mode has not be adapted to the development of the current society, shows a lot of drawbacks: Can't give effective use of modeling data, it hinders the improvement of the social efficiency; Can't do instant settlement, it hinders the development and research of dynamic cost management of construction engineering; Cannot effectively store cost data, it hinders the applied research of reuse thought in the field of engineering cost, etc. And in construction stage, do not take effective means for value-added management on engineering cost. In order to solve the problems above, it must make deep and fundamental change of the mode of engineering cost management, and perfect management concept in construction stage. Therefore, this paper put forward the improvement scheme about engineering cost management mode in construction stage as follows.

2 Discussing the Relationship of Engineering Cost, BIM Technology and Collaborative Management Mode

2.1 Application of Collaborative Management Mode in the Engineering Cost

In the construction process of the engineering, it has emerged collaboration and produced collaborative effect before that the construction unit establishes effective collaborative management mechanism. The specific performance has the following two aspects:

2.1.1 The Performance of Collaboration Under the Institution

Under the development of valuation mode, it has actually achieved a simple collaboration from the quota valuation to the bill of quantities, which greatly improves the controllability and accuracy of the engineering amount [2]. But the bid invitation unit only provides BQ (it is short for bill of quantity) to bidder generally, not the file or model of the calculation process. Therefore, the degree of current collaborative management is not deep and exists at the surface in the form. But it is undeniable that the collaborative effect of engineering cost management has played an important role in promoting collaborative management in the field of engineering cost.

2.1.2 The Performance of Collaboration Under the Society

In the stage of engineering cost settlement or in the stage of progress payment disbursement, there will be such a phenomenon that one participant establishes the amount calculation model, and the other participants use the same one. Some of the phenomenon is advocated by the first party (construction unit), some is allowed by the first party, and some is even without the knowledge of the first party. For example, a third-party (consulting unit) maybe hand the amount calculation model of previous stage such as the bidding stage to other participants. Other participants or a third-party may use it for audit of the next stage. The tangible benefit of this phenomenon to the recipient is that he can save a lot of time in modeling, and has more time and effort to check and modify the model to reduce the error rate; The intangible benefit is that, if the modeler on previous stage knows that the model will be transferred to other people to use and check, he must work more seriously, whether active or passive. This private or not approved behavior lets the participants *compete*, *cooperate* and *coordinate*, and makes spillover effects for each other. In a way, it can be understood as collaboration between the project participants [3].

Therefore, the concept of collaboration has gone deep into the actual work of the engineering cost, and it is conducive to collaborative management mode to carry out.

2.2 Application of BIM Technology in Engineering Cost

BIM is short for Building Information Modeling. It is based on the 3D digital technology, is integrated engineering data and information model, and is a digital expression of engineering facilities physical and functional properties. The scholar named Guanpei He concludes on BIM as *model is the basis, information is the soul, management is the key*, the premise is “*when the owner needs BIM, it can be used everywhere*”. It means that BIM technology must support sharing technology of internet terminal [4].

2.2.1 The Application in Engineering Cost

Engineering cost personnel calculates the engineering quantity by computer through building the model in 1:1, which is a computational 3D construction model by constructional element. Although it is not based on the internet, the model brings basic information of quantity. It belongs to the base of the definition of BIM technology. The calculation software such as Luban soft and Glodon soft can be considered as a kind of BIM. Therefore, BIM technology has been applied in engineering cost [5].

2.2.2 The Other Applications of BIM Technology in Engineering Project

In the present, BIM technology is upgraded in construction stage to achieve the application of *2 WBS* (it is short for work breakdown structure) and *5D BIM* technology. *2 WBS* means *plan WBS* + *actual WB*, and *5D BIM* technology is the 5 dimensions: *3D modeling +1D progress +1D cost*. The BIM technology can control of progress, cost and material procurement plans, and enhance the overall value in construction stage greatly [6].

Therefore, BIM technology plays an important role in the engineering cost, and is also used in project management [7].

2.3 The Relationship Between BIM Technology and Collaborative Management Mode

Collaborative management is based on a large collaborative management platform. Through the platform, restructure time, space and function structure to actualize the participants' competition – cooperation – coordination between each other to generate spillover effects. Therefore, collaborative software is demanded to actualize the collaborative management [8].

BIM technology can work as a collaborative management platform in engineering cost. First of all, BIM technology in the field of engineering cost has been used for a long time, so it can facilitate the participants to operate it on the platform; Second, BIM technology can support the sharing technology of internet terminal, and can be regardless of time and space to work, share and transfer timely. It can solve the problem of *information isolated island*, *applied isolated island* and *resources isolated island* to make the collaboration of information, business and resources.

So, BIM technology can provide the good management platform for collaborative management. At the same time, collaborative management actualizes the value of BIM technology [9].

2.4 The Relationship of Engineering Cost, BIM Technology and Collaborative Management Mode

Engineering cost is the object of management, BIM technology is the measure of management, and collaborative management is the concept of management. Establish a mechanism of collaborative management to make all project participants use BIM technology and collaboration in the engineering cost, and to promote the development of engineering cost management of value-added.

3 Establishing Collaborative Management Model of Engineering Cost Based on BIM Technology in Construction Stage

3.1 Determining the Stage of Application of the Mode

The basic concept of management is to achieve the desired goals and to coordinate activities in human-centered way. For the engineering cost management in design stage, its target can be classified as the management goal. Considering of the effect of design scheme, it also make sure engineering cost economic and rational through optimizing the design scheme. Although this effect is general, but it can reflect the value-added process of engineering cost management by management means [10].

But, in construction stage, the work of settlement audit is called the management of engineering cost. But In fact, it is a misunderstanding. It is just a beneficial method to improve the accuracy of calculated value of engineering cost, it is not a management mean. It means that people have not established good means about the management of engineering cost in construction stage, and also does not take effective management measures.

Although the roughly 80 % of engineering cost has been decided in design stage, but there is a big optimization space in construction stage [11]. And in recent years, the profit margin is low in construction engineering project. It is necessary to pay more attention to the management of engineering cost in construction stage.

Consequently, what this paper states is the narrow sense of engineering cost. And researches on the management of engineering cost in construction stage.

3.2 Analysis of Participant Roles and Their Function

3.2.1 Decision Maker and Its Function

Decision makers: construction unit, namely, the first party, and is the people who establishes the mechanism of collaborative management and make the management goal.

The biggest contribution of the decision maker is to establish a reasonable and effective mechanism of collaborative management to make every participants collaborate. In ensuring the value of engineering cost and under the rational condition, mobilize the enthusiasm of each participant as far as possible, to make the engineering cost economical and actualize management value.

3.2.2 Manager and Its Function

Manager: engineering cost consultation unit. It is engaged by construction unit in the form of contract. Its responsibility is to build the engineering cost model, maintain the collaborative platform based on BIM technology, provide engineering cost data and offer model service for participants in construction stage.

The manager use the bill of quantities valuation model which was built in bidding stage and the unit price of the successful bidder to build a new model in order to make contribution to the collaborative management platform. According to the actual situation, it can assist participants to modify the data and model. And by using the data and model on the platform, it can generate instant engineering cost by the month and the project plan next month to provide the reference for the decision maker (construction unit), in the end, to form instant settlement documents and actualize real-time settlement very month. In the meantime, it can help contractor units and supervision units read and record the data from the collaborative platform to actualize the solution of project timely. And it also can provide convenience for construction unit to seize the solution of project accurately. Manager is also in charge of sorting and filing the engineering data.

3.2.3 Participants and Their Function

Participants: in construction stage, all the *second party* which has signed contracts with the decision maker (construction unit), including the contractor unit, supervision unit and engineering cost consulting unit, etc.

Engineering cost consultation units also has the characteristics of the participants just like other *second parties*. All the participants will make collaborative contributions to engineering cost management in common and get due reward under the effect of the collaborative management mechanism made by decision maker. And all the participants should record the work situation to the collaborative management platform in time, so that other participants could use expediently, and the construction unit could seize the project progress exactly.

3.3 Establishing Mechanism of Collaborative Management

North believes that it may improve the economic efficiency (benefit to somebody and nobody damaged in this case) or the redistribution of income single (one party's or group's earnings is always the loss of others in this case) based on the result of institutional change. And it is the first effect in this paper, namely to increase the net income of society [12].

Consequently, construction units should consider the following two suggestions when construct collaborative management mechanism according to the program:

1. The goal of participants in same stage should be consistent and "against" to the goal of the previous stage.
2. As to the imperfection of contracts we suggest to set up reward systems of the improved contribution and improved compensation. It not only can actualize the target of benefit to somebody and nobody damaged proposed by North, but also can encourage all participants involved in the collaborative development.

For example, targets of engineering cost consultation unit are against to targets of contractor unit in the construction stage currently, so they can't actualize collaboration under this condition. So we will take it as an example to analyze the above two suggestions.

The first suggestion is to manufacture collaborative condition and realize the value management. We suggest settling it by adopting performances of social collaboration based on BIM then makes contractor unit and construction unit supervise and check the cost model and cost data of engineering cost consultation units. It not only can save the repeated time for setting up model to inspect models provided by engineering cost consultation units, but also can encourage engineering cost consultation unit to build model and calculate seriously, through those they can actualize collaboration finally. Therefore, it requires construction unit should set a same target for all participants in the same stage and creating a collaborative condition within a complex large system.

The second suggestion is to realize the value-added of collaborative management. Carry out management activities with the target against the goals of previous stage. The means of optimizing construction process, design scheme and material selection can make engineering cost more effective. Reasonable reward mechanism can encourage all participants to optimize the engineering project. It advocates that set up reward systems of improved contribution and improved compensation to aim for all participants with the consistent target in the same stage and to avoid any participant suffering a loss.

The collaborative management mechanism of contractor unit and engineering cost consultation unit can show as following:

1. Keep the contract of contractor units.
2. Change the constitution of contractual income of engineering cost consultation unit. Remove the additional expenses through audit, and only remain the basic charge on the basis of engineering cost and increase the rate base, make sure to guarantee the profit no less than 1.2 times of the original pattern.
3. Construction unit should establish the collaborative management agreements with all participants including contractor unit, engineering cost consultation unit, supervising unit with the following two points: one is that appoint engineering cost consultation unit to share the architectural model and cost file with

construction unit and contractor unit, actualize real-time settlement, and make engineering cost consultation unit know that construction unit will take the architectural model and cost file for second review or third time review after the completion of project, and if there is problems in engineering cost, construction unit will punish the engineering cost consultation unit for 5 % of the amount of audit change. The other is that it can take following reward mechanism when there is value improvement in construction stage:

(a) As participants who can put forward improvement suggestions, they will reward 10 % of reduction amount in whole cost of construction unit as the improved contribution reward;
(b) Other participants whose contract profit reduced because of the improvement will get 1.5 times of profit margin according to the contract as improved compensation. And encourage project participants to optimize engineering cost actively and actualize collaborative management.

4 Analyzing the Four Target Which the Mode Can Achieve

4.1 Contribution to the Engineering Cost Itself

Avoid the engineering cost personnel determining the engineering cost. Sometimes engineering cost personnel employed by construction units or contractor units are irresponsible and don't have high level of skill. They are careless of the audit of the accounts. Finally the settlement is formed by the mood of engineering cost personnel [13]. However, the cost information kept by BIM technology will be set the limited permission of using and archived as a history for the people who can reuse it at any time. That is to say, there will be as times as be checked in the present and future. So the sense of responsibility and serious manner of cost personnel will be improved naturally. And their professional skills would rise because of the open degree of cost information whether it is intentional or not. The method above can improve the quality of cost personnel in a way. It can achieve the goal of engineering cost in construction stage by this way. So the construction unit can spend money clearly, and the contractor unit can earn money reasonably [14].

4.2 Contribution to the Development of Science and Research

Real-time settlement, BIM technology and collaborative management have made contributions to some fields such as the cost dynamic management, the data reuse and the increase of social efficiency.

1. This mode can set the limited permission of using the building model and data. Cost consultation unit makes real-time settlement of the monthly quotation in order to reduce the phenomenon that contractor unit gives extra benefits to cost consultation unit during the audit. As well as, the more important is to promote all participants to achieve the cost dynamic management of engineering cost for their own unit;
2. The use of BIM has built a building information model and added an effective approach of the storage of cost data. And it can be helped by using it to avoid obtaining project resources in each construction unit and not finding the previous data because of the demission of engineering cost personnel [15]. First of all, BIM technology is used by cost consultation unit, and it can obtain the date through providing a service to the construction unit, and the collection of data from a single unit turns to the concentration for easy management. At the same time, the consultation unit and the construction unit through model use the open data of limited permissions for investment estimation. The second, BIM technology can actualize the network sharing. The data will be uploaded to the internet terminal server by cost personnel. It could be found by anyone who has the permissions according to the related searches. This can avoid data loss because of the change of engineering cost personnel and achieve the effective reuse of construction model and construction cost data [16].
3. Establish up a collaborative management mechanism that can make the all project participants help each other and build only one model in a project. Modifying the model in the future is based on the model which is built today. Realize the situation that one person do things and many people can use them. Sharing the results of collaborative management can improve the social efficiency of engineering cost personnel, etc.

4.3 Contribution to All the Project Participants

That all the participants collaborate with each other can actualize the decreased costs of their own in the case of the unchanged income of every participant. In a way, that is the same thing that the earnings of all the participants are increased. This makes all the project participants prefer to promote the collaborative operation. It result that the collaborative operation can be used widely in other work not just in engineering cost, and can be enhanced the overall advantages of the construction project [17].

4.4 Contribution to the Construction Unit

It is convenient for large real estate company to control multiple projects at the same time. Manager and all the participants can record the physical truth on the collaborative management platform (CMP) by using the sharing technology of internet terminal of BIM. Construction unit can take engineering data of every project at anytime and anywhere, know the project progress and physical truth accurately, and know engineering settlement, cost control and funds operation very well. So it is convenient for large real estate company to actualize real-time management and control [18].

5 Conclusion

By discussing the relationship of engineering cost, collaborative management mode and BIM technology, the three can be combined, and the effective combination can achieve self-organization by the effective collaborative management mechanism made by decision makers. This paper has established the collaborative management mode of engineering cost based on BIM technology in construction stage, has analyzed the necessity of value management in construction stage, has described each role and its function under the condition of the model, and has proposed the two suggestions that should be adopted when the manager establishes a collaborative management mechanism, and finally analyzed the practical significance of the model. We hope it can really promote the development of engineering cost management in construction stage and promote the value of engineering cost management.

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A Study of Value-Based Consumer Behavior Under E-Business Environment

Shuang Xiao and Jiang Tian

Abstract This research studies the consuming process under the E-business environment using qualitative and quantitative methodologies. In this study, the qualitative analysis is based on consumer value theory. After the consumer consumption way and purchase decision process having been analyzed, the paper builds up a theoretical model of consumer behavior decision in the process of consuming. In the electronic commerce environment, consumer behavior decision still can be divided into three stages, including pre-purchasing, purchasing and post-purchasing. This paper respectively discusses the key influential factors affecting consumer in every stage. On the foundation of qualitative analysis, the consumer value is analyzed with quantities methodology, which gives the key influential variable of consumer behavior mathematical definition, builds up the model of value-based consumer behavior, and finally gives the procedure of solving the model. This model focuses on consumer behavior under the influence of product price, quality, information, time, etc. To verify this model, simulation method is advised to be used in further studies.

Keywords Consumer value • Consumer behavior decision • E-business environment

1 Introduction

With the development of internet technologies, E-business arouses wide concern among traditional enterprises. Statistics show [1], by the end of December, 2012, the number of netizen (cyber citizen) in China had broken through half-billion

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and reached 564 million. Meanwhile, the popularizing rate of internet has reached 42.1 %. The number of internet consumers has been 242 million, paying 42.9 % of the consuming bill. From the above, it is clear that online shopping has attracted a large scale of consumers, and the online marketing channel is going to step into a mature developing stage. Under E-business environment, consumer behavior has become a hot issue.

Compared with traditional single marketing channel, consumers' various and individual demands are better satisfied under E-business environment [2, 3]. Consumers can search the information, purchase and comments of products through traditional marketing and E-business channel [4]. Consumers' perception of value has a close relationship with their consuming decision. It will be easily affected by the media, family and social groups [5]. Thus the study of consumer behavior is conducted on the basis of customer value theory.

Woodruff claimed that customer value is customers' comments and preference for product attribute, actual effect and performance when the product is used under a specific situation to realize the consumption goal [6]. Oliver put forward a customer value concept framework, and the customer value includes the following three parts: cost value, quality value and feel performance [7]. Philip Kotler raised the concept of customer delivered value, and he also divided customer delivered value into two parts: total customer value and total customer cost [8]. Sheth put forward that market selection is a function decided by multiple consumption values, and each value has different influences on selection at different situation. Meanwhile, they believe that the factors influencing consumer behavior includes functional value, social value, emotional value, cognitive value and situational value [9]. Lee and Overby divided consumer value into two dimensions: utility value and experience value. For the consumer, the utility value is used to measure the function of goods or services; experience value indicates the seller's ability to provide consumers with a positive sense of emotion [10].

2 Consumer Behavior Decision Model Under E-Business Environment

In the environment of E-business, the product can be delivered to customers from both physical stores and online stores, as shown in Fig. 1.

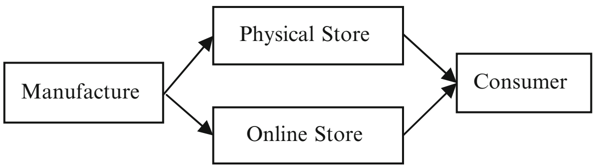

Fig. 1 Double channel structure

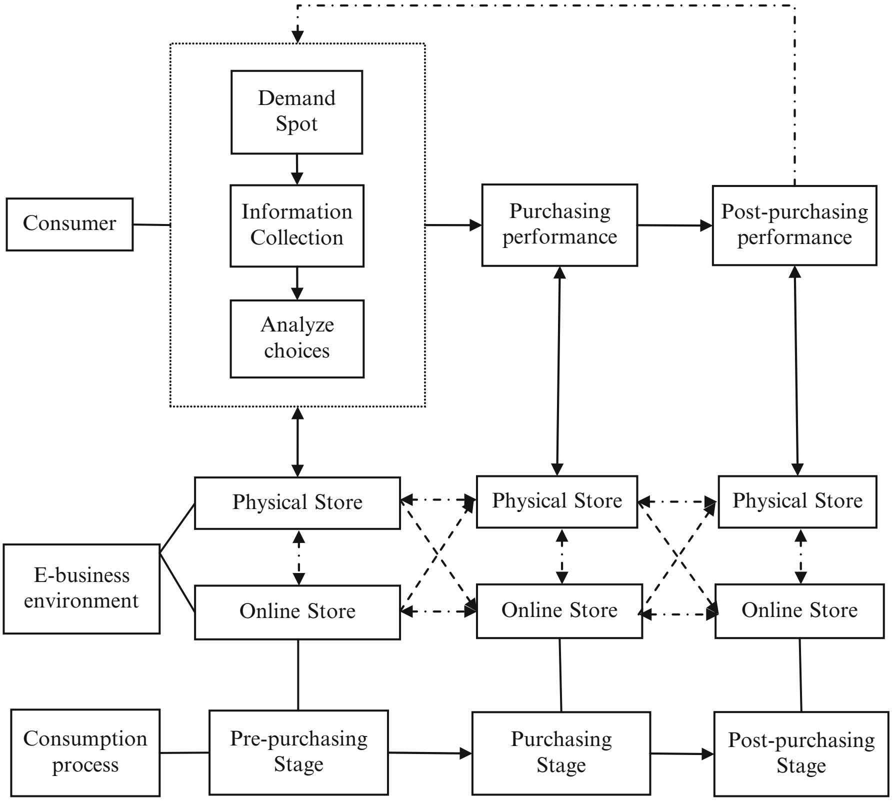

Fig. 2 Model of consumer behavior decision in the process of consumption

Based on the above analysis, this paper sets up a dynamic model of consumer behavior decision in the process of consumption, as shown in Fig. 2.

Consumption process can be divided into three stages including pre-purchasing, purchasing and post-purchasing. Pre-purchasing stage refers to demand confirmation, information search and analysis and selection. Purchasing stage refers to purchasing performance, and post-purchasing refers to consumers' performance after having purchased. During the whole purchasing process, consumers will face the issue of seller-choosing. Interaction also exists in online and offline channel. The combination of channels indirectly increases the value of consumers.

At the pre-purchasing stage, the more information consumer gets, the easier consumer can judge to make a decision. Besides, price is still a key factor for consumer to make a decision and it is also the critical variables of price and time at the pre-purchasing stage.

At purchasing stage, consumer's choice will be affected by the availability of purchasing channel, service, creation, payment convenience and delivery time, etc. These factors derive from purchasing channel. The availability and payment convenience can be shown from time-saving measures.

At post-purchasing stage, consumer tries out the product directly, and utilizes the value of product quality and after-sale service. At this stage, the quality and function of product itself have close relationship with consumer's satisfaction. Meanwhile, the total value obtained during the purchasing process is realized by consumer.

3 Consumer Value Analysis

Based on the above analysis, the consumer value in this paper mainly includes: price, quality, information and time. This model, on the basis of the maximum of consumer value, in the first place studies the function of consumer value, which refers to the function of four variables including price, quality, information and time. The function is expressed as follows:

$$\mathrm{V} = \mathrm{F}\,(P, Q, I, T)$$

V- Consumer Value; P-Price; Q-Quality; I-Information; T- Time Value

The functional equation of Consumer Value is:

$$\mathrm{V} = \omega_1 \mathrm{V}(P) + \omega_2 \mathrm{V}(Q) + \omega_3 \mathrm{V}(I) + \omega_4 \mathrm{V}(T) \tag{1}$$

Here ω_i represents the weight of influencing factor, $\sum_{i=1}^{4} \omega_i = 1$. Under E-business environment, consumer purchases products from different marketing channels are various in terms of price, quality, information and time. These elements of consumer value can be analyzed and presented by quantitative model. Here i represents sellers (from both physical stores and online stores). Suppose that $L = \{1, 2, \ldots i, \ldots N\}$ acts the set of sellers, different seller i provides different price (P_i), quality (Q_i), information (I_i), time (T_i) for the same consumption demand. Consumer Value of product price can be represented in the total consumer value expression as:

$$\mathrm{V}(P) = \varepsilon_i \times P_i \tag{2}$$

"ε_i" stands for price sensitivity. In accordance with purchasing experience, product price is inverse proportion to purchase motive. Each P_i corresponds ε_i for a consumer.

Kim and his fellows in the price sensitivity distributed model suggest that the cheaper a brand sets the price, the less sensitivity of price acts. Therefore, the less influence is on the consumer's motive [11]. Price sensitivity is an exponential function of the difference between real price and expected price.

$$\varepsilon_i = -\alpha^{P_i - P_e} + k$$

α is a parameter greater than 1; k is a constant (it depends on the population statistics of online consumer, for instance, high-income groups are less sensitive to price than low-income groups); P_e is expected price from consumer. As different consumers have different expectation for the same brand, P_e is uncertain. Generally, we regard average $\overline{P}$ ($\overline{P} = \frac{1}{N}\sum_{i=1}^{N} P_i$) as a same kind of product of different brands instead of P_e, i.e. the value function for product price is:

$$\mathrm{V}(P) = \left(-\alpha^{\mathrm{P}_i - \overline{P}} + k\right) \times P_i \tag{3}$$

Outlier avoidance [12] claims that the closer the product quality is to consumer's expectations when referring to a marketing channel, the more sensitivity the channel raises [12]. Thus, the expression of quality value is similar to that of price value, as shown by mathematical formula [13]:

$$\mathrm{V}(Q) = \mathrm{h}_i \times Q_i \tag{4}$$

Hereinto, h_i is a sensitivity parameter for the product quality of seller i:

$$\mathrm{h}_i = \beta^{\mathrm{Q_i} - \overline{\mathrm{Q}}} + \mathrm{r}$$

$0 < \beta < 1$, r is a constant (it depends on the population statistics of online consumer). Obviously, the closer the product quality is to consumer's expectations, the more sensitivity the consumer feels. In the same way, consumer's expected quality can be replaced by the average quality of the products with the same function from different sellers, which is $\mathrm{Q_e} = \overline{\mathrm{Q}} = \frac{1}{\mathrm{N}}\sum_{\mathrm{i}=1}^{\mathrm{N}} \mathrm{Q_i}$, thus,

$$\mathrm{V}(Q) = \left(\beta^{\mathrm{Q_i} - \overline{\mathrm{Q}}} + \mathrm{r}\right) \times Q_{\mathrm{i}} \tag{5}$$

The spread of product information has the same effect on consumer behavior as public praise. From the seller's point of view, product information brings both positive and negative influence on consumer [14]. The equation of Information Value is:

$$\mathrm{V}(I) = M_i \times \delta_i \times I_i \tag{6}$$

M_i is the number of consumer affected by information from seller i, i.e. receiver of information; δ_i is a parameter of consumer susceptible to information affection, which is the psychological feature of consumer. It is also affected by population statistical characteristics. Therefore, $\delta_i = \theta$ is commonly accepted. The equation of information spreading effect goes:

$$\mathrm{V}(I) = M_i \times \theta \times I_i \tag{7}$$

This paper defines consumer's time value on the basis of time utility linear model. T_i represents the time consumer takes on choosing seller i, including consulting, purchasing and delivery. There is only one seller among the available sellers occupying maximum time ($T_{\max}$) of consumer. The expression of consumer's time value goes:

$$\mathrm{V}(T) = \left(\frac{T_{\max} - T_i}{T_{\max}}\right)^{\lambda} \tag{8}$$

λ means the factor of sensitivity of consumer to time benefit and loss [15]. When $0 < \lambda \le 1$, λ is a factor of consumer sensitivity to time loss; when $\lambda > 1$, λ is a factor of consumer sensitivity to time benefit.

From above we get the Consumer Value Model:

$$\begin{aligned}
\mathrm{V} &= \omega_1 \mathrm{V}(P) + \omega_2 V(Q) + \omega_3 V(I) + \omega_4 V(T) \\
&= \omega_1 \varepsilon_i \times P_i + \omega_2 \mathrm{h}_i \times Q_i \\
&\quad + \omega_3 M_i \times \delta_i \times I_i + \omega_4 \left(\frac{T_{\max} - T_i}{T_{\max}}\right)^{\lambda} \\
&= \omega_1 \left(-\alpha^{P_i - \overline{P}} + \mathrm{k}\right) \times P_i + \omega_2 \left(\beta^{Q_i - \overline{Q}} + \mathrm{r}\right) \times Q_i \\
&\quad + \omega_3 M_i \times \theta \times I_i + \omega_4 \left(\frac{T_{\max} - T_i}{T_{\max}}\right)^{\lambda}
\end{aligned} \tag{9}$$

When consumers face with a variety of consumer decisions, they will consider a number of factors to maximize the value of the decision-making. The Schuler score can be used to determine the values of ω_i and these indicators: price (P_i), quality (Q_i), information (I_i), and time (T_i). Therefore, consumer value brought by seller i can be calculated. But consumer decision-making behavior depends on $\max[\mathrm{V}_1, \mathrm{V}_2, \ldots, \mathrm{V}_n]$.

4 Exemplification

Suppose that we choose Store A as a physical store in Chengdu, and Store B as its competitor online. And both stores share a certain number of consumers. At the beginning, we make a questionnaire survey on the consumers shared by the two stores. In the survey, consumers give marks for the stores respectively in terms of the price, quality, and information provided and shopping time. When grading the factors between [l, 10], "10" expresses great satisfaction, "1" means very dissatisfied. Results of the survey can be seen in Table 1. The average price $\overline{P}$ is 7.5; average quality $\overline{Q}$ is 8.1; and the valuation of information receiver of each store is

Table 1 Factors from consumers influencing the value of sells

Factors influencing value	Weight (ω_i)	Store	Online store
Price P_i	0.36	8.0	6.5
Quality Q_i	0.29	8.5	7.6
Information I_i	0.17	6.8	7.8
Time T_i	0.18	7.2	8.7

Table 2 Parameter values of population statistical characteristic

Parameter	Parameter values	Parameter	Parameter values
α	2	k	1
β	1/2	r	1
θ	1	λ	2

5. Customers are dissatisfied with the sellers who spend long time. Therefore, $T_{\max}$ is 1. Other parameters can be influenced by the population statistical characteristics; the valuation can be seen in Table 2.

5 Conclusions

This paper builds up the consumer behavior decision theoretical model under E-business environment. Based on the value theory, the author studies the consumer behavior model with quantitative methodology, and highlights the attribution of information value, time value to consumer value under E-business environment. To verify this model, simulation method is advised to be used on an applicable simulation platform. Besides, further studies are supposed to take more factors into consideration to make the model more comprehensive.

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The Comparative Study of Innovations Among Regions in China, the United States and Japan

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Abstract This paper measured the innovation level among regions of China, the United State and Japan and made comparative research between regions of different countries. A cluster and Factor analysis method was used in dealing with the data set. The content and conclusion of the paper are as follow: Firstly, this paper made comparative research of innovation level among regions. We have gotten the conclusion that the inequity of innovation exists in all these three counties. There are still obvious differences between developing countries and developed countries. We can also find the differences between countries with broad regions and countries with small regions.

Keywords Comparative • Innovation • Measurement • Regional

1 Introduction

The science and technology innovation investment in China strengthens year after year and the innovation output has a high growth. From the data of China we can only see the innovation quantity and growth speed, but in the age of economic globalization we must study the relative position of Chinese innovation level in the world. From the international comparison, we can find out the advantages and disadvantages of China. Generally speaking, the absolute quantity of our country's R&D investment is equivalent to the level of moderately developed countries [1].

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The proportion of the R&D investment to GDP reflects a relative strength of national R&D input. Our country's level was slightly lower than the United States. The source of the R&D investment includes government R&D investment, enterprise R&D investment, bank loan etc. [2]. Among them, the enterprise investment and government investment was the main ways of R&D investment in the major countries. In majority, most of the countries' R&D investment is the enterprise investment which can achieve more than 50 %. Enterprise and the government is both the main body of scientific and technological innovation [3]. In the aspect of the innovation output such as the invention patent authorization number, several international comparison researches show that Chinese innovation output number is not lower than the number of the developed countries and moderately developed countries [4]. Chinese independent innovation level in the world is higher [5]. The innovation level of the countries is of great differences and the phenomenon exists generally [6, 7]. Even in one country, the distribution of innovation resources may not uniform. Therefore, it is necessary to introduce the typical different areas of the country to do a comprehensive comparison [8]. In this paper, we will research the uneven distribution of innovation among regions in different countries.

2 Methodology

This research is based on provinces among different regions of China, the United States and Japan. In the empirical analysis, we gave attention to both relative index and absolute index, stock index and flow index. Innovation investment evaluation index mainly include the R&D funds input and the R&D/GDP. We chose the patent license number [9], patent of invention authorization number and appearance design authorized number as innovation output evaluation index. By comparative study on the regional innovation among these three countries, we can determine the relative position of different provinces in China, the United States and Japan, analysis the differences and similarities, and find out the advantages and the shortages, draw lessons from other countries, improve China's regional innovation level and reduce regional differences. This paper used the principal components analysis, clustering analysis and order analysis.

2.1 Principal Component Analysis

The four index indicators [10] selected for Principal component analysis [11] include: R&D input, the R&D/GDP, the number of university and the number of invention patent output. The analysis results of the rotation of factor loading

Table 1 After rotation of factor loading matrix

	Component 1	Component 2
R&D/GDP	−5.65E-04	0.978
University number	0.92	−1.35E-02
Patent number	0.827	−0.186
R&D input	0.793	0.213

matrix shows in Table 1. Two principal components were automatically extracted by the SPSS system and the factor cumulative contribution rate is 80 %. The main composition of orthogonal is independent which can avoid the correlation caused by original index in clustering deviation. Another important purpose of the principal component analysis is to ascertain the index weight for comparison among cluster in the next chapter.

2.2 *Cluster Analysis*

The regional research samples include 129 samples of China, the United States and Japan. Regional innovation unbalanced development exists in these three countries. With clustering analysis method [12], the total samples are divided into several categories. We can use the sort order and the cluster to judge regional innovation level. In order to eliminate the collinearity problem between variables [13], we use the principal component analysis to extract the main factor, which makes the classification results more scientific. The four index indicators selected for the clustering analysis include: R&D input, the R&D/GDP, the number of university and the number of invention patent output. The reason of Selecting R&D level as indicators is that we have accumulated a large number of data of R&D and empirical studies of many scholars also show that there is a close relationship between R&D level and region's science and technology, economic development potential. R&D/GDP is a relative quantity which can reflect the strength of regional R&D investment and make up the defects of absolute index and bring more objective evaluation of the innovation input intensity; The number of universities reflects a regional innovative environment; Invention patent output is main index to measure a regional innovation output.

We did the cluster analysis by the two principal components and the European square distance. When the value is 1, the samples will be divided into 6 clusters, and the biggest cluster includes 101 samples. Then we should do the further cluster analysis in the 101 samples in order to get more detailed clustering results. The result is that when the threshold was 3, the 101samples will be divided into 6 types.

3 Results

From these three kinds of samples, we can see that the sample number of each group is not uniform, and the biggest group contains 45 areas. The third clustering analysis should be done. According to the threshold 6, the remainder 45 samples can be divided into 3 groups. So far, a total of three clustering analysis have been done and the 129 regions wad divided into 12 categories. The clustering results are shown in Fig. 1 and we can see that there are three layer structures, each layer represents a clustering result. It is shown that through the names of some regions in

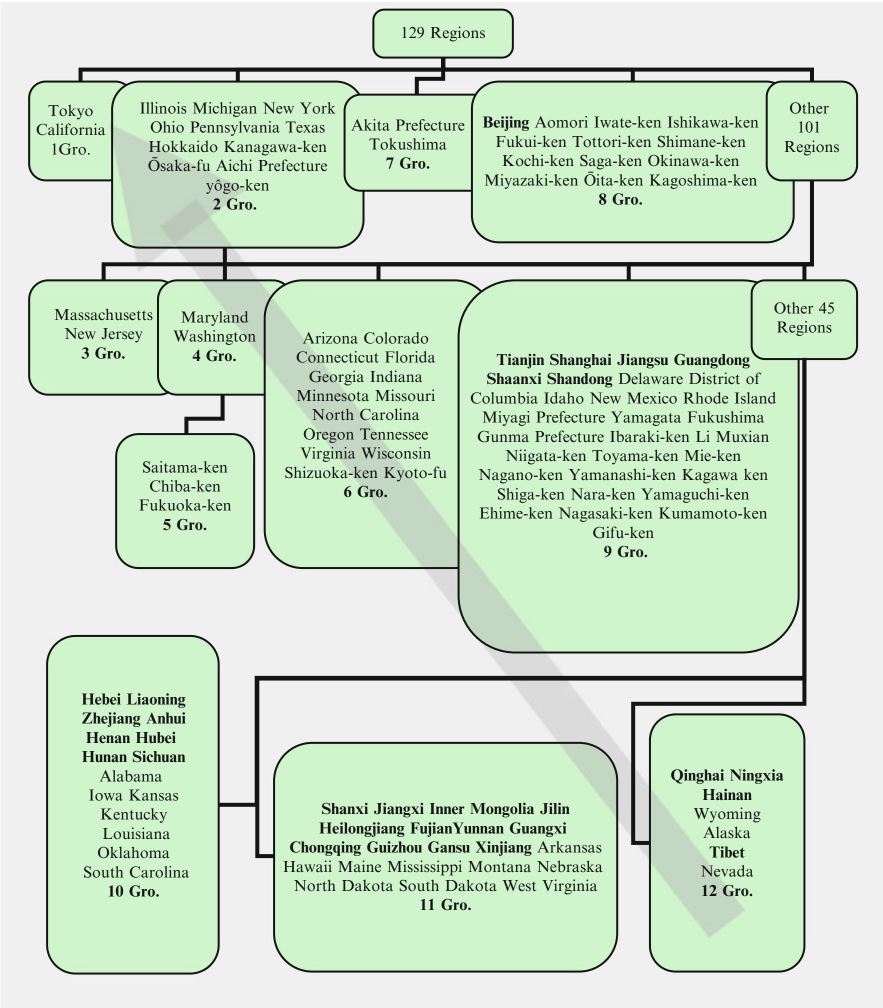

Fig. 1 The innovation level classification map

Table 2 Normalized weight

Index	x_j	x_1	x_2	x_3	x_4
Weight	ϖ_j	0.156	0.303	0.245	0.296

X1 = R&D/GDP, X2 = number of university, X3 = invention patent awarded, X4 = R&D

the group, we can roughly guess the innovation level of this group, such as Tokyo and California in group one is most likely belong to the group with the highest innovation level and the twelfth group with China's Tibet is likely to be in the group with minimum innovation level. In the later chapters we will carry on the index ranking and comprehensive index ranking. From diagram I we can also clearly see the distribution of the 31 provinces of China in each category. The first clustering analysis separated Beijing, the second analysis identified the next six provinces and the third analysis divided the rest of the 24 provinces. The results reflected that the western and eastern provinces of China belong to different categories, from which we can see that innovation level in Chinese eastern and western provinces is different. Using the principal component analysis to determine index weight

The above cluster analysis got 12 categories, and the next step of work is to research the 12 categories of by comparative analysis, it has to be decided on a comparative evaluation standard. The best way is to determine the weight of the four index [14] used before. There are many kinds of methods, in this paper, by using principal component to determine weight, we not only eliminate the influence of the correlation coefficient, but also avoid the subjective factors of experts. The concrete steps are as follows. First of all, the standardization of data, each data divided by the general arithmetic mean value, which can be expressed as follows, = / (k means areas, j means index), is the standardization of the index [15]. The purpose of this method is to eliminate the influence of the dimension, and thus we can rank the data within groups. Secondly, the extraction of main ingredients in the four index, we can get two principal components, yi (i = 1, 2); two feature vectors (i = 1, 2); two feature vectors after rotation (I = 1, 2), we can get, $y_{ki} = \sum_{j=1}^{4} l_{ij} x_{kj}$ $(i = 1, 2;\ j = 1, 2, 3, 4;\ k = 1\ to\ 129)$, the factor score of each sample point is $D_{ki} = \sum_{i=1}^{2} w_i y_{ki} = \sum_{i=1}^{2} \sum_{j=1}^{4} w_i l_{ij} x_{kj} = \sum_{j=1}^{4} a_j x_{kj}$

$$a_j = \sum_{i=1}^{2} w_i l_{ij}, w_i = \lambda_i \Big/ \sum_{n=1}^{2} \lambda_n,$$

λ_i is the eigenvector after the principal component extraction, $\varpi_j = a_j / \sum_{j=1}^{4} a_j$ $(j = 1, 2, 3, 4)$, is the weight of x_j, the calculation of the index weight is shown in Table 2 through above steps.

4 Discussion

We can estimate the integrated innovation index of the 12 regional categories by the weight in Table 2. Firstly, we calculate the mean value of each index in the 12 groups, and then get the comprehensive innovation index of each group by using the weight as Table 3 shows. And then, we can analysis the comparison among the 12 groups. The purpose of the comparison of the comprehensive innovation index and kinds of innovation index comparison is to sort the 12 kinds and give the innovative feature of each group. The specific result is shown in Table 4. Through Table 4 we can clearly see the integrated regional innovation level and individual index level of each group. The comprehensive ranking order is similar to the group order, except group 5, 6, 7. By observing other index, we can find that although the comprehensive ranking row of the seventh group (akita, Howard island) is five, the index of this group is lower than any other groups except the index R&D/GDP. So we should use comprehensive ranking and other indexes to carry out the comprehensive evaluation. It can be seen that the first comprehensive ranking of the first group (Tokyo, California) ahead of other innovation indicators in addition to the R&D/GDP ratio, the absolute value of R&D investment is three times the second, and the patent output is seven times the second, the number of colleges and universities is nearly twice the second. The innovation level of group 1 can be seen ahead. Group 1 belongs to the type of high input, high output, technical resource-intensive innovation. One possible reason is that Tokyo and California is two most economically developed regions of the United States and Japan, gathering a large number of high-tech enterprises, universities and other innovative resources, well-known high-tech Silicon Valley, and Stanford University and other schools in the state California, provides a convenient conditions of joint innovation between enterprise and college, which are the reasons for its innovative ahead. Group 2 contains six states in the United States and six in counties Japan, and they are basically high-input high-yield category, but its level of innovation is

Table 3 Innovation index of the 12 groups

	Comprehensive	R&D/GDP	University	Invention patent	R & D investment
Group1	10.31	0.77	5.08	23.57	9.72
Group2	2.79	0.86	2.75	3.78	3.04
Group3	2.29	1.10	1.03	2.42	4.09
Group4	1.61	1.27	0.83	1.11	3.00
Group5	1.37	0.81	2.35	0.57	1.32
Group6	1.05	0.56	1.17	1.13	1.11
Group7	1.39	5.16	0.68	0.04	1.24
Group8	0.90	2.70	0.75	0.09	0.76
Group9	0.69	1.25	0.84	0.22	0.62
Group10	0.45	0.39	0.78	0.21	0.34
Group11	0.23	0.34	0.37	0.11	0.13
Group12	0.09	0.25	0.11	0.04	0.04

Table 4 Innovation level distribution of the 12 groups

	Comprehensive	R&D/GDP		University		Invention patent		R&D investment	
Group	Ranking	Grade	Ranking	Grade	Ranking	Grade	Ranking	Grade	Ranking
Group1	1	Medium−	8	High*	1	High*	1	High*	1
Group2	2	Medium–	6	High	2	High	2	High	3
Group3	3	Medium+	5	Medium	5	High	3	High	2
Group4	4	Medium+	3	Medium−	7	Medium+	5	High	4
Group5	6	Medium−	7	High	3	Low	6	Medium+	5
Group6	7	Low	9	Medium+	4	Medium	4	Medium	7
Group7	5	High*	1	Low	10	Low*	11	Medium+	6
Group8	8	High	2	Medium−	9	low*	10	Medium−	8
Group9	9	Medium+	4	Medium−	6	Low	7	Low	9
Group10	10	Low	10	Medium−	8	Low	8	Low	10
Group11	11	Low	11	Low	11	Low	9	Low	11
Group12	12	Low	12	Low	12	Low*	12	Low*	12

Note: “*”, means more higher, “+” means more than a little, “−” means a little smaller than a significantly lower level than the Group 3, also belong to the high-input high-yield group, the comprehensive level somewhat less than group 2, mainly because of the low level of the number of colleges and universities. Through this analysis method are compared for each group of area, concrete results are given in Table 4, listed in the contents of China's 31 provinces, autonomous regions, distribution of Group 8 to Group 12, the ranking is 8–12. We can see China's regional distribution in position by comparison group. Beijing belongs to Group 8, and 12 counties in Japan in the same group, which is not to be in a group with other provinces in China. This group is characterized by low absolute R&D investment, the low patent output, low number of colleges and universities; high R&D/GDP. Beijing is China's scientific and technological innovation one of the active region, it seems that Beijing does not converge to this group, and need special study, the index value is 1.41,3.810,0.725,0.608,1.509, the composite index is 1.41, the overall level of innovation is similar to the fifth group, but the group five is college-intensive area, the indicators fail to meet requirements. The reason is higher R&D investment value, ranked third in the overall area, in line with the set of features, the number of colleges and universities also in line with the characteristics of the group . Overall Beijing should be in group 5.

Tianjin, Shanghai, Jiangsu, Guangdong, Shaanxi, Shandong ranked in Group 9, which contain four states in United States and Japan's 12 counties. The characteristics of group 9 is the R&D input level below the average, the invention patent output is low, relatively medium level of investment in universities and R&D. The group 9 is in the lower level in the overall sample. Hebei, Liaoning, Zhejiang, Anhui, Henan, Hubei, Hunan, Sichuan and other provinces came in the first 10 groups, and six states in the United States in the same group, as shown in Fig. 1. Group 10 and group 9 is only difference in the amount, there is no qualitative difference, which is in the low level of group. Shanxi, Inner Mongolia, Jilin, Heilongjiang, Fujian, Jiangxi, Guangxi, Chongqing, Guizhou, Yunnan, Gansu, Xinjiang is in 11 groups, with low level of innovation. Ningxia, Qinghai, Hainan, Tibet is in group 12, with a very low level of innovation, belong to the same group of Wyoming, Nevada, Alaska in the United State. The specific level of innovation is shown in Table 4.

5 Conclusion

The following conclusions can be obtained from the evaluation of the above analysis: First, the regions of the three countries dispersed in different groups, each mixing, the imbalance of the visible area of innovation is widespread in the United States, Japan., the level of innovation of the three countries cross each other, each country's different regions belonging to high and low innovation class. China has more advanced innovation areas, the United States and Japan also have relatively backward area. Second, In China's 31 provinces, autonomous regions, Beijing belongs to the middle and upper levels, the areas in group 9 belong to the lower level, the areas in the group 10 are at the downstream level, lagging behind in the group 11, in group 12, the area is very backward. Third, the innovation polarization phenomenon is more obvious, there are 48 regions, from the group 1 to group 8, the vast majority of regions distribute in the 9–12 group, the level of innovation gap is obvious. Fourth, the contribution of relative indicators (R&D/GDP) on the overall level of innovation is small, because the right is only 0.156, and from the above analysis it can be seen that area with a high level of innovation is almost with lower R&D/GDP value, lower than the overall average, because the areas with high level of innovation are usually economically developed areas, with the high level of GDP, and R&D investment to GDP ratio is not very high.

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Research of the Informed Trading Probability Monthly Effect in Chinese Stock Market

Jia-yi Li and Zhen-ming Fang

Abstract Basing on the return rate monthly Effect, the informed trading probability was combined with return rate for research in sight of market structure, and percentage monthly risk-adjusted return using Fama and French three-factor model, regressing the multi-factor on two-stage. PIN of September is the lowest in the year, showing negative relationship with percentage monthly return, the result is different with empirical results in foreign market. Impact factors for PIN monthly effect are analyzed including size of company, liquidity risk.

Keywords Fama-French three-factor model • Informed trading probability • Liquidity risk • PIN effect

1 Introduction

Market microstructure has been the important content on financial field. In this field, we pay more attention to the area on what the information influence price formation, using the probability of information-based trading as the measure for information distribution. Easley et al. (2002) [1] estimate the probability of information-based trading (PIN) for every stock and show that as PIN increases, expected returns increase, which the positive between PIN and return. But in recently some researches find the PIN decrease with return in January. So, we also verify the phenomenon in the Chinese market and find different state. In this paper we figure out what drive the phenomenon and explore the alternative explanations.

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The January effect is referred to the return is higher in January than other calendar months. The PIN monthly effect is that the PIN is significant abnormal in some month, and the phenomenon is more prominent for small stocks.

Next we discover the return is the highest in the month that PIN is the lowest in year. Some literatures address the monthly effect of liquidity premium. Therefore, to verify if this seasonal PIN-return pattern is driven by liquidity, we use the Amihud (2002) illiquidity measure [2] as the proxy variable for liquidity measures, to see if the explanation is correct. At the same time, we also consider the size as factor.

Taken together, we check the relationship between the PIN and return, analysis the PIN monthly effect among different size stocks, and explore the trading motive of institutional investors. Our concern in the paper is PIN which is different from other researches on January effect. Some literature has checked the return in January and find it significant positive in March and April [3]. Some literature has explained the January from the habits of consumers [4].

Our research has provided the new perspective to realize behavior of institutional investors, as well as giving the help to understand information-asset pricing ability.

2 Methodology

2.1 Three-Factor Model

Fama and French (1992) [5] found Beta had been weak in explanation on stock return which the factors of market size, BE/ME, E/P has been greater on. Using the Fama and French (1993) three-factor model [6], we calculate the percentage monthly risk-adjusted return, ADR, to reflect the true situation.

$$R_i - R_{fi} = \beta_0 + \beta_m MKT + \beta_s SMB + \beta_h HML + \varepsilon_i \tag{1}$$

MKT is market premium, SMB and HML include the size, amount of market value rate factors. Some literatures have confirmed the three-factor model could explain the return in Chinese market, which fit for our research. Process of risk adjustment is as follow.

$$R_{jt} = E_{t-1}\left(R_{jt}\right) + \sum\nolimits_{K=1}^{K} \beta_{jkt} f_{kt} + \varepsilon_{jt} \tag{2}$$

$E_{t-1}(R_{jt})$ is the expected rate of return, and f_{kt} is the some risk factor during the t stage.

$$E_{t-1}\left(R_{jt}\right) = R_{ft} + \sum\nolimits_{K=1}^{K} \beta_{jkt} \lambda_{kt} \tag{3}$$

R_{ft} is the risk-free rate, and λ_{kt} is the risk premium, so risk adjustment rate of return is counted as follow.

$$R^*_{jt} = R_{jt} - R_{ft} - \sum\nolimits_{K=1}^{K} \beta_{jkt} \left(\lambda_{kt} + f_{kt}\right) \tag{4}$$

2.2 Informed Trading Possibility Model

Traders are divided into two categories which are informed and uninformed traders, and the process of trade is Poisson process [7]. If informed-traders have found the good news, they submit buy orders. On the contrary they submit sell orders.

PIN is defined by the arrival rate of informed trades being divided by the arrival rate of all trades, and it is the index for measure informed trades [8]. According the EKOP model:

$$PIN = \frac{\alpha\mu}{\alpha\mu + \varepsilon_s + \varepsilon_b} \tag{5}$$

In the formula, α is the probability of news, μ is the arrival rate of informed trades, and ε_s, ε_b is the uninformed-trade arrival rate of sell and buy orders. We calculate the month PIN by maximum likelihood estimation.

2.3 Regression Model

Some literatures suggested that the relationship of PIN and return had been affected by liquidity [9]. We make the multivariate regression model for confirm influencing factors.

$$R_{jt} = \beta_0 + \beta_{1t} SIZE_{jt} + \beta_{2t} PIN_{jt} + \beta_{3t} LIQ_{jt} + \varepsilon_{jt} \tag{6}$$

We use the regression to control for other risk characteristics, and then we run the following time series regression of the coefficient of PIN or LIQ on dummy variable, SEP, which is equal to one if the coefficient comes from January and zero otherwise

$$\beta_t = c + \gamma SEP + \eta_t \tag{7}$$

LIQ is illiquidity index which is Amihud (2002) liquidity measure by modeling price and trading volume. They have confirmed illiquidity affects more strongly small firm stocks, thus explaining time series variations in their premiums overtime. We use LIQ as the liquidity premiums measure.

$$ILLIQ_{jt} = \frac{1}{N_{jt}} \sum_{\tau=1}^{N_{jt}} \frac{|R_{j\tau}|}{DVol_{j\tau}} \tag{8}$$

Table 1 Month pin

Month	PIN small	PIN middle	PIN big
1	0.168	0.123	0.113
2	0.149	0.129	0.119
3	0.145	0.130	0.120
4	0.120	0.117	0.109
5	0.123	0.109	0.095
6	0.147	0.145	0.118
7	0.170	0.151	0.124
8	0.169	0.149	0.135
9	0.114	0.103	0.099
10	0.152	0.132	0.107
11	0.137	0.124	0.118
12	0.143	0.128	0.107

$R_{j\tau}$ is return on day τ in month t, and $DVol_{j\tau}$ is trading volume. N_{jt} is the number of trading days. ILLIQ higher suggests the liquidity level more low.

3 Results

The basic data are composed of all A stock in Chinese market from 2008 to 2011, excluding the stocks which have not at least 15 day returns. As a result, the sample contains 670 stocks, and we also use the number of trading days, day returns, trading volume, market capitalization at the end of year, which is supplied by RESSET Database.

The first question is whether there is PIN month effect in Chinese market. The stocks are sorted into small/middle/big by size, and calculate the month PIN for group. Table 1 shows the PIN of every month by different size.

We present the result for month PIN, and find September has lowest PIN. The Phenomenon is more significant in small stocks. At the same time we find the PIN is higher in July and August than other months.

Then, we want to know whether the return is different in September from other months. Using the risk-adjusted return to certify the question, we obtain the result. Table 2 shows the month return.

The month return is highest in September and lowest in December, which is more significant in small stock. Thus we confirm PIN month effect exists in Chinese market.

These empirical findings give us a meaningful clue to the PIN and return pattern. Based on the observation the seasonal PIN effect is mostly confined to small stocks. PIN is negative with return in September, although PIN-return pattern is not obvious in other months. As Easley et al. (2002) address, stocks returns should be higher in response to a high level of information based trading as a compensation for

Table 2 Month return

Month	Return small	Return middle	Return big
1	0.1015	0.0365	−0.0062
2	0.0649	−0.0564	0.0406
3	0.0174	−0.1114	−0.0758
4	−0.0250	−0.0056	0.0613
5	0.0156	0.0090	0.1312
6	−0.0625	−0.1066	0.1151
7	0.1229	0.1055	−0.0149
8	0.1650	0.0923	0.0715
9	0.3132	0.1575	0.0678
10	0.0003	−0.0860	−0.0190
11	0.2360	0.2326	−0.0467
12	−0.0722	−0.1454	−0.0169

information asymmetry. The question deserves more investigation which will be conducted in the next section. Moreover, we explore a potential explanation and distinguish this phenomenon from other empirical regularities. We will also see a differential return reversal pattern across PIN in September, especially for small stocks, suggesting the PIN effect.

4 Discussion

Duarte and Young (2009) [10] argue that the PIN and return relationship might be driven by the liquidity effect. They decompose the whole PIN effect into two different components, the illiquidity effect and the pure information effect, and show that average returns are affected by the former. In order to see if the PIN effect is driven by liquidity, we control for liquidity by adding a liquidity measure to the regression [11]. Specifically, we employ the variable which is the Amihud (2002) illiquidity measure. We run the regression including a liquidity variable in Eq. (6), and the test results are present in Table 3.

We find a positive PIN–return pattern in September even when we include a liquidity measure in the regression. This suggests that the January PIN effect is not affected by liquidity. On this result, we further conjecture the pattern is related with institutional investors [12]. In September, they pay more attention on the stocks which PIN is low. The selling pressure from institutional investors is strongest for low-PIN stocks, and tends to decrease in PIN Our intuition is consistent with the literature on institutional investors [13]. Institutional investors show a herding behavior. Therefore, given a different ownership across PIN [14], if institutional investors have a similar motive and move together, they will show a differential selling pressure across PIN.

Table 3 Liquidity variable test

Cons	Non-September	September
β_2	0.00015	0.06018
t	0.02387	2.69627
β_3	0.00018	−0.00070
t	0.53656	−0.58439

5 Conclusion

The paper confirms a seasonal pattern of the PIN effect in September in Chinese market, and we certify the liquidity factor and other explanations behind our finds. The following are the points we would like to make.

First, we indeed find the seasonal pattern for the PIN effect. The portfolio returns show a negative relationship between PIN and returns in September. The regression test results also confirm a significant difference in the PIN–return pattern between September and other calendar months, especially for small stocks. Second, this PIN–return pattern can be attributable to the behavior of institutional investors. Combined with the distribution of institutional investor across PIN, investor's motive explains the decreasing PIN–return pattern in September. Third, the 'PIN effect' has never been addressed in the literature and is not the same as other anomalies [15] such as the 'January momentum effect'. Finally, we believe that the PIN seasonal pattern is related to some empirical issues in the empirical studies utilizing PIN [16], and it also sheds a new light on the role of institutional investors. The state should be paid more attention to research and explore the more reasons for this new subject.

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An Empirical Research on the Influence of Information Synergy on Nuclear Power Affiliated Enterprise's Innovation Performance

Yu-qiong Li, Dong-mei Zhao, and Kai Chen

Abstract Through studying on the related articles about Information Synergy and Nuclear power affiliated Enterprise Innovation Performance, this paper proposes a conceptual model which can explain the relationship between Information Synergy and Nuclear power affiliated Enterprise Innovation Performance. We acquire sample data by distributing questionnaires by means of e-mails, by conducting interviews or using other means. And using SPSS 16.0, it examines the affecting degree empirically of different dimensions of Information Synergy (Information Quality, Information Acquisition) on Nuclear power affiliated Enterprise Innovation Performance. And it is concluded that Information Quality has more significant influences on Enterprise Innovation Performance than Information Acquisition. Thus, this paper provides a theoretical basis for Nuclear power affiliated enterprises to promote the innovation performance.

Keywords Empirical research • Information synergy • Innovation performance • Nuclear power affiliated enterprise

1 Introduction

In the era of information economy, the value and significance of information, as a kind of important strategic resources of the enterprise, is difficult to measure, and it plays an important role in economic and social development. Making full use of the effectiveness of information is not only the duty of those who use information (i.e. enterprise leaders, ordinary workers, etc.), but also a necessary process of enterprise development. The effective management of information will become one

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of the key factors for an enterprise to achieve success and would affect its life and death. The keen competition of the market has prompted some enterprises to cooperate through merger and acquisition, industry alliance, supply chain and so on, in order to achieve a win-win situation. Through in-depth exchange of information resources, enterprises can obtain opportunities such as technology complementary, the innovation cost and risk sharing and quick access to the market and enhance enterprise innovation performance. Therefore, the relationship between information synergy and enterprise innovation performance becomes the research topic of this paper.

2 The Connotation of Information Synergy and Measurement

2.1 The Meaning of Information Synergy

Collaborative thought was put forward by professor H. Haken in the 1960s, and was widely used in the field of computer [1]. Then scholars both at home and abroad made a widely and deeply study of the thoughts of Information Synergy. Information Synergy refers to the use of the thought of Synergy to make deep processing of information, combine a variety of resources, and form drive in the information system, to make a clear direction for the transferring of information, and make synergistic effects in each link of information system, prompting system to evolve at the balance point and maintain system dynamic balance [2]. Enterprise Information Synergy is a kind of comprehensive coordination which needs to be implementing in different level of enterprise. Namely: (1) the information synergy between the enterprise's internal departments, employees in product development, raw material purchase, the product quality management, and other areas; (2) the information synergy between the enterprise community in supply chain, value chain and so on; (3) the information synergy between enterprise and internal biosphere (Banks, government, research institutes and other departments). This paper holds that information synergy is a management ideology that the user effectively organize and harmoniously use all kinds of information during the process of performing sorts of business activities, so as to realize the purpose of eliminating "information island".

2.2 The Measurement of Information Synergy

The specific measurement scale of Information Synergy is shown in Table 1.

Table 1 The measurement scale of information synergy

Dimension	Items of measurement
Quality degree	(x11) can be more timely to reach needing information from other enterprises or departments in the process of collaborative
	(x12) can reach more useful information from other enterprises or departments in the process of collaborative
	(x13) can reach information of higher accuracy from other enterprises or departments in the process of collaborative
	(x14) can reach agreement, form standardized and effective legal official document during consultation with other enterprises
	(x15) can often organize formal of informal communication with other enterprises or departments
Acquisition degree	(x21) can have a good communication with other enterprises or departments
	(x22) can be easier to reach other enterprises or departments' information than before
	(x23) can reach more types of other enterprises or departments' information than before
	(x24) can reach more detailed information of other enterprises or departments than before
	(x25) the organization structure of enterprises is flat, of less intermediate level, and information dissemination channel is short

Origin: Uzzi [3], Das and Teng [4], Mehmet [5], Zhao Yunpeng [6], Zhu Wenping [7]

3 Nuclear Power Affiliated Enterprise and Innovation Performance

3.1 The Meaning of Nuclear Power Affiliated Enterprise

Nuclear power, as its name indicates, is a renewable source of energy that changes the internal energy which nucleus contains into available electrical energy. At present, with the development of nuclear-related technology, nuclear power has become an effective complement to traditional energy because it does not emit greenhouse gases and is free from contamination. Moreover, the development of nuclear power has become one of the six key projects in the energy industry during the 12th Five-Year Plan as the optimization of energy structure. Such development has improved the proportion of clean energy such as water electricity, nuclear power, wind power, solar energy and so on, promoted innovation in advanced energy technologies and developed wind energy, solar energy, biomass energy and the emerging energy technology and equipment technology for the uses for clean coal, nuclear energy, intelligent power grid, new energy vehicles, distributed energy. We must try to promote restructuring and fusion between energy industries, as well as energy and related industry to establish a modern energy industry system and realize the intensive and efficient development.

Nuclear Power Affiliated Enterprise refers to the companies, enterprises or other economic organizations that have direct or indirect relationship with nuclear power, have been owned or controlled by the third party, or have other relationships with the third party in capital, management, and marketing around the nuclear power equipment manufacturing, uranium mining, nuclear power technology, and spent fuel processing. A few days ago, a policy as “huddling development, dislocation development and related development” was put forward by some people in Nuclear Power Affiliated Enterprise in some areas, and they strive to improve nuclear power consciousness as well as to speed up the pace of nuclear power development. Nuclear Power Affiliated Enterprise needs a certain degree of cooperation to become bigger and stronger.

3.2 The Meaning and Measurement of Enterprise Innovation Performance

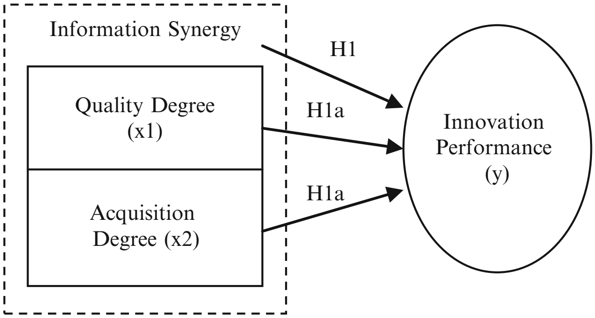
Innovation Performance includes the indexes to measure the innovation activities effect and efficiency. Generally, patent number is considered as its proxy variable abroad. This paper, according to Nishiguchi [8], Bidault [9], etc., measures the enterprise Innovation Performance from five indexes that most scholars agree. Measuring items are: (1) the number of company’s development of new products each year (or service) is larger; (2) compared with the local company in the same industry, the company has more patents; (3) compared with the local company in the same industry, new product (or service) brings more value accounts for the total sales; (4) compared with the local company in the same industry, new products (or service) develop very rapid; (5) compared with the local company of in the same industry, innovative products (or services) have higher success rate [10–12].

4 The Empirical Research and Analysis

4.1 The Hypothesis

Experts and scholars both at home and abroad have made a lot of researches on the relationship between Information Synergy and Enterprise Innovation Performance which mostly shows that Information Synergy has a positive influence to enterprise’s innovation performance. As Gerwin and Moffat [13] and other scholars believe that information communication is one of the main factors effecting the process of enterprise’s innovation. Rhonda et al. [14] verify the influence of

Fig. 1 Concept model



information sharing to enterprise's performance through the experiments named multi-agent simulation. And they think in dynamic environment, information sharing can improve the performance of the enterprise [14]. Xiong Li, Meng Qingguo, Yan Bing, etc. think enterprise can effectively reduce the uncertainty of from outside through the Information Synergy, and at the same time, reduce the possibility of existence of "information island", and what's more, be good for decision-making and more efficient allocation of resources, make the enterprise get better performance. Dougherty [15] argues that employees have different world of thought. If it cannot fully cooperate, it will lead to extension of new product development cycle or poor market performance. Information Synergy plays an important role in enterprise's survival and development because of the uncertainty of information environment and the rapid flowing of information. Information resources can enrich one's mind, make them have more knowledge, and enhance their innovation ability and improve the innovation performance in product development, design, manufacture and management, and other areas. Thus this paper, taking the Nuclear Power Affiliated Enterprise for example, puts forward the research hypothesis:

Hypothesis 1 – H1: High Information Synergy plays a significant positive role on the Enterprise Innovation Performance.
Hypothesis 2 – H1a: The better of Information Quality Degree, the faster growth of Enterprise Innovation Performance.
Hypothesis 3 – H1b: The higher of Information Acquisition Degree, the faster growth of Enterprise Innovation Performance.

4.2 Conceptual Model

Based on the research on the related theory and the research hypothesis, this paper constructs the concept model shown as Fig. 1.

Table 2 KMO and Bartlett's Test and Cronbach's alpha coefficient table

	KMO and Bartlett's Test		Reliability statistics	
	Kaiser-Meyer-Olkin measure of sampling adequacy	Sig. of Bartlett's Test of sphericity: approx. Chi-square	Cronbach's alpha	N of items
Information quality degree	0.872	.000	0.873	5
Information acquisition degree	0.777	.000	0.779	5
Information synergy	0.837	.000	0.809	10
Innovation performance	0.847	.000	0.893	5

4.3 Data Processing

4.3.1 The Reliability and Validity Analysis

Based on the method of issuing questionnaire to employees and senior of Nuclear Power Affiliated Enterprise in Hunan, Guangdong, Gansu and so on, we get the original first-hand data. In order to verify the above hypothesis, this study sent 289 formal investigation questionnaires and got 240 questionnaires back. The recovery rate is 83.04 %. According to the related concept, variable measure adopted Likert's measurement of the five dimensions as given a proposition, the respondents should give comment. We deal with the collected data using the statistical software SPSS16.0. Connected with the statistical analysis of the data, we verify the model and test the hypothesis in this paper.

The Validity Test

The survey of this questionnaire is discussed repeatedly to make a choice, and through preliminary examination in small range to try to ensure the questionnaire has certain content validity. We adopt Exploratory Factor Analysis method to test the questionnaire structural validity. As the statistics showing, the common degrees for all the items in questionnaire are above 0.5, showing the questionnaire's structural validity achieves the basic requirements.

We made KMO measure and Bartlett's Test on each measuring item. The result (Table 2) is that the KMO value of the Information Quality Degree, Information Acquisition Degree and Information Synergy are 0.872, 0.777 and 0.837, between 0.7 and 0.8, which means the group of variable data is fit for factor analysis. At the same time, the significant level of their statistical value in Bartlett's Test is 0.000, which is less than 0.01, showing that the data fits for factor analysis once again.

In this paper, we take it as the standard to select factors that whose characteristic root is greater than 1, and use the Principal Component Analysis and the method of

Table 3 Exploratory factor analysis results

	Component	
Items of measurement	1	2
(x11)	.811	.047
(x12)	.855	.076
(x13)	.771	.030
(x14)	.804	.135
(x15)	.806	.162
(x21)	.020	.712
(x22)	−.018	.711
(x23)	.111	.731
(x24)	.168	.742
(x25)	.136	.724

Table 4 Anova

Model		Sum of squares	F	Sig.
1	Regression	168.869	573.079	.000
	Residual	70.131		
	Total	239.000		
2	Regression	173.154	311.618	.000
	Residual	65.846		
	Total	239.000		

Varimax to calculate the loading coefficient of different factor's measurement item (Table 3). It can be seen from Table 4 that there are two factors respectively stand for Information Quality Degree, Information Acquisition Degree with its characteristic root greater than 1. At the same time, through the method of varimax it can be concluded that the maximum load of measurement item of the same variable is 0.7 higher than other factors, which shows that this scale has better discriminated validity.

The Reliability Test

Reliability coefficient is a reflection of the reliability of the size of the statistics. In this study, Cronbach's (α) coefficient (Table 3) is taken as reliability criteria. The standards are as follows: $0.5 < \alpha < 0.7$, credible; $0.7 \leqq \alpha < 0.9$, very credible; $\alpha \geq 0.9$, completely credible. For general basic research, reliability to 0.7 can be accepted. In this study the Cronbach's coefficient (Table 2) were 0.873, 0.779 and 0.809. It shows that the consistency of questionnaire is good and of high reliability. It corresponds to the requirements of social science questionnaire with internal consistency.

Table 5 Regression coefficient and significant test table

Model		Unstandardized coefficients		Standardized coefficients		
		B	Std. error	Beta	T	Sig.
1	(Constant)	2.959E-16	.035		.000	1.00
	Quality degree	.841	.035	.841	23.939	.000
2	(Constant)	2.685E-16	.034		.000	1.00
	Quality degree	.841	.034	.841	24.654	.000
	Acquisition degree	.134	.034	.134	3.927	.000

Note: Dependent variable: innovation performance

4.3.2 Hypothesis Test

In this paper, we take Information Quality Degree and Information Acquisition Degree as the independent variable and the Enterprise Innovation Performance as the dependent variable to make a multivariate stepwise regression to test the hypotheses. From Table 4 we can see that the data of each cross position of the column of Sum of Squares and the row of the Regression of each model increases from 168.869 to 173.154 in the process of stepwise Regression, indicating that model is improved. And F statistics significance of probability of each model is less than 0.01 which means there is a significant linear relationship between Information Quality Degree, Information Acquisition Degree and Innovation Performance.

The regression coefficient and significance test table (Table 5) shows T test situation can see, the entire coefficient is significant on the 0.01 level, different from zero. Therefore, the two variables can be explanatory variable to explain the change of Enterprise Innovation Performance, and at the same time, it shows that it does not have multi-collinearity problem. According to the results of regression analysis, we can get the following regression equation: $Y = 0.841\ X1 + 0.134\ X2$. Through the above correlation and regression analysis, it proves the proposed theory hypothesis and the model of the research.

5 Conclusions and Suggestions

5.1 Research Conclusion

This paper aims to study how different dimensions of the Information Synergy influence Innovation Performance of Nuclear Power Affiliated Enterprise. Through the statistical analysis of previous chapters, we can draw a conclusion that:

1. Whether information, as one of the important strategic resources for the enterprises to gain the competitive advantage and sustainable development, can be timely, accurate and effective obtained becomes a key to improve innovation

performance of Nuclear Power Affiliated Enterprises. The statistical analysis of the front section makes the research hypothesis 1 verified, which supports that a high Information Synergy plays a significant positive role in the Enterprise Innovation Performance.

2. Via the stepwise regression analysis, we can see that the information regression coefficient of Information Quality Degree is 0.841, and the regression coefficient of Information Acquisition Degree is 0.134. Then, we can conclude different dimensions of Information Synergy (Information Quality Degree, Information Acquisition Degree) have different influence on the Innovation Performance of Nuclear Power Affiliated Enterprise, and the effect of Information Quality Degree on Innovation Performance of Nuclear Power Affiliated Enterprise is more significant than Information Acquisition Degree.

5.2 Suggestions

This paper, by using the method named empirical research and doing statistics analysis and regression analysis on the sample data, aims to verify the concept model of the relationship between Information Synergy and Innovation Performance. The results will provide reference of important value to achieve efficient allocation of resources, collaborative operation and create economic benefits, which mainly displays in Nuclear Power Affiliated Enterprise, cannot just proceed Information Synergy for Information Synergy but pay attention to its quality during formal or informal communication or other ways of Information Synergy. It can thus enhance the core competitiveness of the whole enterprise and promotes the enterprise innovation performance.

5.3 Research Deficiencies

This paper makes a regression analysis on the relationship between Information Synergy (Information Quality Degree, Information Acquisition Degree) and Innovation Performance of Nuclear Power Affiliated Enterprise, and achieves some conclusions having a certain reference value. However, due to various reasons, it needs to be further perfected.

5.3.1 Limitation of the Measurement

The design of quantitative measurement index of information synergy and innovation performance is not comprehensive enough, which may cause the result of the measurement deviation.

5.3.2 Limitations of the Concept Model

This paper studies only the influence of Information Synergy on the Enterprise's Innovation Performance, and does not consider other factors such as social relationship capital, environmental uncertainty which may have intermediary or adjustment effect on their relationship.

In view of the above shortages, future studies will focus on perfecting measurement index and concept model to study the influence of Information Synergy on Enterprise Innovation Performance.

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Study on Methods of Optimizing Information Resource Management Based on Knowledge Service Capability

Ye Zhao and Fan Yang

Abstract Starting from the present development status of information resource management in a knowledge service institution (KSI), information resource management (IRM) is studied in this paper based on the improvement of knowledge service capability. First, the related concepts of IRM based on knowledge service capability (KSC) are put forward, and then the management elements, management modes of IRM and optimization of management configuration are studied. On this basis, the management elements are collated and the key factors are extracted and optimized to enhance the service effectiveness of KSI.

Keywords Management element • Management mode • Knowledge service capability • Optimization of configuration

1 Introduction

With the development of information technology and the rise of knowledge economy, information service capability becomes one of the core capabilities in a modern KSI. Accompanying the rise of networked information resources, which are rendering irregular, scattered, this puts forward higher requirements for information resource management. *On Information Resource Management in a Library in Digital Environment* written by Qing-jun SUN presents that automation, networking and digitalization of resources in a library is a necessary phase for a modern library to be transformed into a digital one [1]. *Library Information Management in network impact* written by Liang CAO also believes that it challenges traditional library for

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new technologies to develop at top speed. It is imperative to achieve library digitized management of books and reference materials and promote library information management to transform into a modern type from a traditional one [2].

Meanwhile the proportion of information service in knowledge service is growing larger and larger. Reasonable and high efficient information resource management has become a key factor in achieving knowledge service. *Human Resource Management of a library and Information Resource Construction* written by Hai YU presents that information resource construction is the basis of library core competence and the important support for a library to develop service activities [3]. *Research on Knowledge Service Capability and Capability Evaluation in a Library and Intelligence Institution (I, II) written by* Yue-fen WANG etc. puts forward that knowledge service capability regarding knowledge as the fountain supports knowledge service system to operate effectively and decides the transformation and performance of knowledge service resources and is an acting force for a library and intelligence institution to win competitive advantage and is also the fundamental drive for library and intelligence industry towards the future. So it is the primary problem how a knowledge service institution will cope better with the impact of informationization and networking, strengthen IRM and enhance knowledge service capability [4, 5].

2 Connotation of IRM Based on KSC

2.1 An Overview of IRM Based on KSC

IRM is a series of management activities evolved with the purpose of improving KSC, on the basis of social economic resources, tightly around modern management thinking and management theory. It is generally believed that the rational allocation of resource management by effective means can promote the development, utilization and value increment of information resources to realize its own value.

KSC is the capability for a library and intelligence service institution to be guided by knowledge service strategy, according to the user's specific problems and requirements in a changing environment, integrating its all internal resources, by controlling and coordinating the knowledge service flow to operate effectively, transforming internal resources into knowledge products or service which can be externalized, to a core predominance ability for an institution [4].

2.2 Core Issue of IRM Based on KSC

The core issue of IRM is a process of integrating the internal factors and enhancing KSC. It evolves tightly around the following three issues:

1. Management factor issue: Starting from system management theory, first we pay attention to the internal composition of the system and their organic connection and interaction. So it is the key to enhance the core service capability to survey and analyze carefully its intrinsic factors to find out the important factors and their action mechanism and integrate the advantages. In the process of knowledge service, we must firmly grasp each stage for knowledge service and strengthen the construction of the core factors and the weak links starting from the service elements to improve its service capacity.
2. Management mode issue: for the managers, they integrate systematically the management factors according to the needs of the aim. Then, they adjust the restrictive relationships among the factors to ensure the best whole performance. For KSI, they must be on the basis of their own basic conditions, analyze the factors which are influencing IRM internally, allocate them reasonably to improve the efficiency of the system.
3. Optimizing management issue: For the management factors to play a performance, it will be influenced by internal structure, at the same time constrained by the external environment of the system. Optimizing the performances is to adjust the structure, reduce the conflicts among the internal factors, and improve the management structure and hierarchy by systematic analysis. For IRM, adjusting the train of thought of management, transforming the ideas, introducing the advanced theories is the transition point for KSI to improve information resource management capability.

3 Research on Influencing Factors

3.1 Research on Management Factors

For a library management institution, the first task is to clarify the various indicators which are influencing IRM, then conduct the targeted analysis and discussion to improve and optimize them. Therefore, this paper summarizes the related factors that influencing IRM and gives their hierarchy diagram.

3.1.1 Architecture and Hierarchy Relationships of IRM Based on the KSC

The structure and levels of IRM are based on the infrastructure. It regards requirements for improving KSC as traction and is divided by influencing factors.

As Fig. 1 shows, internal environments consist of two layers: hard power layer and soft power layer. Hard power includes four areas: library resources, service equipments, resource capability and staff configuration. Soft power layer includes interlibrary exchange, personnel quality and management mode. External

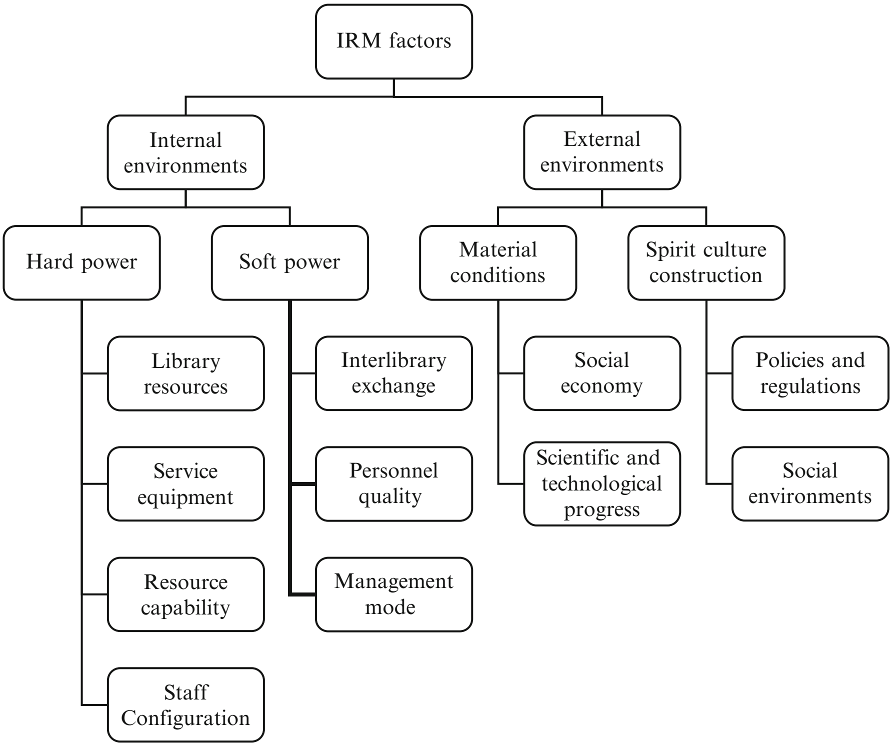

Fig. 1 The index system of managing factors

environments consist of two layers: material conditions and spirit culture construction. Material conditions include social economy and scientific and technological progress. And spirit culture construction includes policies and regulations as well as social environments.

3.1.2 Index Points Analysis of IRM Based on KSC

Study on Factors of Internal Environments

Study on internal environment is the inner mechanism research which can influence KSC. It studies the whole problem mainly beginning with KSI's own internal influencing factors, including two aspects: hard power and soft power.

Hard power researches the relevant factors from hardware, including four aspects: library resources, staff configuration, service equipment and resource capability [6].

Soft power studies the internal factors influencing KSC from the internalization strength, including the three factors: interlibrary exchange, personnel inherent quality and management mode.

Analysis of Factors of External Environments

The research on external environments is the constraint relationship for the entire external environments to IRM. It influences the service objects and service conditions of IRM and is an indispensable part in IRM. It researches the questions mainly from material conditions and spirit culture construction

3.2 Study on Management Mode

A complete set of effective mechanism must be established to support the operation of the entire institution for KSI to improve the management reliability. Secondly, the whole performance is optimized by optimizing the management factors, reducing the contradictions and conflicts between internal and external factors, optimizing and adjusting the structures. To achieve the above aims, we must first find out the principal contradiction and key factors restricting the development of management level.

3.2.1 Necessity of Priority Analysis of Influencing Factors

IRM is composed of several elements. It mainly includes four elements: The first is hard power. The second is soft power. The third is material conditions and the fourth is spirit culture construction. These four elements are composed by many smaller and more specific point factors. There are many factors restricting KSC. It is the necessary condition to determine the primary development factor in IRM for improving management level.

3.2.2 Priority Degree Analysis of the Factors Influencing on IRM for KSI [7]

To Determine the Hierarchy Structure

First, we should distinguish the levels of various factors relevant to the problems, and then construct a hierarchical model with a tree structure. It is generally divided into objective layer, criterion layer and project layer, as is shown in Fig. 1

Weight Calculation Based on Entropy [8, 9]

Entropy is a quantum to measure uncertainty of a system in information theory. The greater information quantity is, the smaller uncertainty is and the smaller entropy is as well. On the contrary, the smaller information quantity is, the greater uncertainty is and the greater entropy is as well. Entropy value method is mainly depending on the magnitude of information which each index value contains to determine the index weight. The common procedure of entropy method is:

(a) The decision matrix $X = (x_{ij})_{m \times n}$ is standardized and the standardized matrix $P = (p_{ij})_{m \times n}$ is obtained and normalized as

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \; (1 \leq i \leq m, 1 \leq j \leq n) \tag{1}$$

(b) Calculate the entropy value for the jth index:

$$e_j = -k \cdot \sum_{i=1}^{m} p_{ij} \ln p_{ij} \; (1 \leq j \leq n) \tag{2}$$

Where, $k > 0, e_j \geq 0$.

(c) Calculate the coefficient of variation of the jth index. For the jth index, the greater the variation of the index value is, the greater the effect on scheme evaluation is and smaller entropy value is. On the contrary, the smaller the variation is, the smaller the effect on scheme evaluation is and the greater entropy value is. So coefficient of variation is defined as

$$g_j = 1 - e_j \; (1 \leq j \leq n) \tag{3}$$

(d) Determine the index weight. The weight of the jth index is:

$$w_j = \frac{g_j}{\sum_{j=1}^{n} g_j} \; (1 \leq j \leq n) \tag{4}$$

To Calculate Combination Weight

The result is got by calculating the combination weight for the project layer to the target layer.

By the above calculation, the sequence weight indexes for each layer are obtained.

Table 1 Factor weight table

Library resources	Service equipment	Resource capability	Staff configuration	Interlibrary exchange	Personnel quality
0.0404	0.1622	0.1769	0.0404	0.1434	0.0875
Management mode	Social economy	Scientific and technological progress	Policies and regulations	Social environment	
0.0489	0.06	0.06	0.072	0.108	

$$w_i{}^{(k)} = \sum_{j=1}^{n_{k-1}} p_{ij}{}^{(k)} w_j{}^{(k-1)} \; (i = 1, 2 \ldots, n)$$

Where, p_{ij} is the weight vector for the element on layer k to that on layer $k-1$, w_i represents the relative weight for the indexes between the same layer.

$w^{(k)} = (w_1{}^{(k)} \cdot w_2{}^{(k)} \; \ldots \; w_n{}^{(k)})$ can be got by collating the indexes.

To Get Factor Weight List

After referring to relevant data, consulting the professionals, we rate the above factors. Here questionnaire is commonly used to rate. Re-using the above project to calculate, we get the table for factor weight as Table 1

Research Result

According to the running result for the program, the top three factors are resource capability, service equipment and interlibrary exchange.

3.3 Research on Optimizing Management Mode

According to the research result, the main weak links of management must be strengthened, and the prominent problems must be pertinently solved.

3.3.1 Regulation and Control of Macro Management Mode

According to the research result, from the main body, the influence for internal factors is greater than that for external factors in KSI. It means that KSI should mainly depend on the improvement in intrinsic ability to strengthen information resource management and enhance knowledge service ability.

Secondly, the top three factors influencing resource management capability are resource capability, service equipment and interlibrary exchanges. Therefore, in order to develop internalized knowledge service ability, the foremost task is to meet the impendent needs for diversification, specialization of knowledge. While modern equipment, convenient service system platform are the basis of realizing knowledge service. Knowledge sharing, resource integration are the necessary conditions.

3.3.2 Conception on Optimization of Subindex Points

1. Optimization of library building: Though in network environment, the role of library building resource seems to become weaker and weaker, a user has a very high degree of dependency relative to the virtual environment. Relying on the environment and atmosphere of KSI, it can effectively stimulate the people's interest in reading. With the help of professional service platforms, one-stop retrieval service can be completed quickly and effectively improve the efficiency of knowledge service. Exchange and interaction between users and the service personnel can reasonably guide a user and improve service quality.
2. Optimization of staff configuration: In KSI, the service personnel themselves are the staff to produce knowledge products and provide the specific services. So the service personnel are the guarantee for realizing knowledge service value. Only there is a group of new librarians who not only has profound professional knowledge and network skills at their finger ends, but also has good cultural literacy and the capability of acquiring, organizing and propagating information, can IRM be effectively done.
3. Optimization of service equipment: The development of modern technology provides a strong support for IRM to develop innovatively. Application of information software changes the flow and mode of the traditional knowledge service. Informationization means plays a key role especially for deep mining and post-processing of information. A knowledge service platform is a medium to contact users and service agencies. It provides a virtual environment so that a user can effectively acquire the required services. A knowledge service platform is the gateway where knowledge service can be achieved and also a window for the personnel who are serviced to acquire knowledge.
4. Optimization of information resources: Information resources include the collected network resource information, electronic information retrieval system and resources which a service agency has processed to form and the information resources which the associated users require for [10].

Optimized configuration for soft power:

1. Optimization of interlibrary cooperation and exchange: In digital environment, it is difficult to realize the whole construction of a digital library and fully satisfy the demands for many readers' growing knowledge service only by virtue of their own strength to "go it alone". So in foreign countries, a new development mode – "knowledge service alliance" which is developed in digital environment

emerges as the times require. Through the network, united catalogue, holdings query and document delivery are carried out and the complementary advantages, mutual exchange of needed products are indeed realized between knowledge service agencies which have participated in the cooperation. Using the associated model from abroad for reference can effectively solve the problem of domestic information resources [11].
2. Optimization of the personnel's inherent quality: The service personnel are the front line service personnel who communicate with users, and are even more the working people who process knowledge deeply. Their service attitude, working enthusiasm, knowledge level and spirit influence the knowledge service quality.
3. Optimization of management mode: Information theory, control theory and system theory are fully introduced into management. A set of management mode is established based on the whole, overall situation, making the part and whole unify dialectically to improve the intrinsic performances for a knowledge service agency.

Study on optimization of material conditions:

1. Optimization for social economy to the people's existing conditions: With the economy in our country to increase at top speed, the people's living standard is increasingly improved, which make most of the people walk out of the problems in finding enough food and clothing and have energy to study further and improve. This has important strategic significance on improving our people's quality.
2. Improvement for scientific and technological progress to information tools: The development of network storage medium creates the conditions for mass information to be integrated and transmitted on a large scale. With the relevant service software, rapidly acquiring, organizing, processing of information and data mining can be done to liberate the service personnel from the heavy manual labor to carry out the deeper level of service activities.

Study on traction of spirit culture construction:

1. Guide for policies and regulations to information resource management: The development concept of "Outlook on scientific development" means that economic development mode which is set up mainly on the basis of high energy consumption, high pollution and other natural resources will be transformed into the development one mainly relying on scientific and technological progress and taking information, knowledge as the basis of resources. So the government increases the relevant investment so that the management and construction of information resource can have great progress.
2. Guide for the social environment to people's study attitude: When the spiritual life of the people is better, they will invest more energy in knowledge study and improve their own knowledge level. And when the whole society advocates science and culture, it can effectively arouse the people's interest in study and make the society progress. On the contrary, the whole society will be stagnant and the people's living level will also be backed.

4 Conclusions

With the informationization process accelerated, it has already become the priority task of strategic deployment for KSI to strengthen the construction of information resource management. The research result in this paper shows that constructing multi-layer, overall linkage structure of information resource; optimizing resource allocation, building a virtual library, constructing a knowledge service platform; integrating information resources, enhancing comprehensive ability are the important measures by which KSI seizes the opportunities to develop preferentially in the future development.

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Research on Financial Statements System Based on Enterprise Resource

Yu-ju Li and Rong Li

Abstract Financial statement is an important carrier to transmit accounting information to external users. With the development of social economy and the variation of users' demand, financial statements system should be improved and perfected. As the current Chinese financial statement system which based on enterprise assets has its limitations, this paper puts forward ideas about financial statement system based on enterprise resource according to the Resource Theory, and suggests statement which reflects corporation's competence, resource value and comprehensive income should be added to the current financial statement system. The financial statement system, based on enterprise resource, consists of balance sheet, income statement, cash flow statement, resources equity statement, comprehensive income statement, statement of goodwill index and the changes of its value. And the elements of basic statements and extensible statements should take different confirmation and measure methods.

Keywords Asset • Competence • Enterprise resource • Financial statement system

1 Introduction

As a business language, accounting provides information through financial statements. The financial statements system is not always static, but it is improved and perfected with the development of social economy and the demand of users. In fact, financial statements system of every country in the world is in the process

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of development and change. The trend is that species from single to multiple, the submit object from the inside to the outside and the content from simple to complex.

Domestic and overseas scholars and accounting professional groups have done a lot of research on financial statement system, among them the United States and the UK are in the lead [1]. American Accounting Association (AAA) made a suggestion to reform statement in 1991. It included self-generated goodwill should be recognized in the statement if it can be measured reliably, and add employees report and value added statement. The United States Financial Accounting Standards Board (FASB) rebuilt financial statement system in 1984, the system consisted of statement of financial position, income statement or comprehensive income statement, cash flow statement and statement of owners' investment and assignation to owners. The American Institute of Certified Public Accountants (AICPA) came up with an assumption to prefect statements in 1994, it included distinguish between core and non-core item, using mixed measurement attributes, and non-core items were measured at fair value. In 1997, FASB proposed that besides income statement, statement of comprehensive income should be prepared to reflect enterprise net income and other comprehensive income.

British accounting field also made great efforts on the improvement of financial statements. UK Accounting Standards Board (ASB) successively issued many reports, such as *corporate report, the future financial and accounting reports model, financial information preparation.* In 1992, ASB put forward the idea that adding "all have been confirmed gains and losses table" to report all of the enterprise performance. In 1995, ASB extended the basic financial statements to four, which is income statement, all have been confirmed gains and losses table, balance sheet and cash flow statement.

Recently, IASB and FASB do a lot of work about reformation on financial statements, and jointly issued *Preliminary Views on Financial Statement Presentation* in October, 2008. They changed balance sheet to statement of financial position, and combined the income statement and comprehensive income statement to comprehensive income statement, and classified all kinds of statements according to operating activities, investing activities, financing activities [2]. But statements after reformation still based on assets, they couldn't reflect the value of enterprise resources and changes in competence and couldn't provide the information of enterprise value and wealth changes.

Many domestic scholars conducted research on the issue of the financial statements from different points of view. Wang Songnian and Xue Wenjun (1999) proposed the establishment of a comprehensive performance reporting system [3]. Ge Jiashu and Chen Shoude (2001) studied the financial statement from the point of view of the quality evaluation system and put forward high-quality financial reporting evaluation criteria [4]. Xie deren (2001) conducted research from the perspective of the logical relationships between the financial statements, analyzed the reasons for the collapse of its logic and propose the target of reconstruction [5]. Zhu Kaixi (2007) put forward the direction of the reformation of the value reporting from the perspective of accounting errors and the accounting equation [6]. Huang Xiaobo (2007) built the model of financial statements from the respective of generalized capital and property rights [7]. Zhan Meisong (2008) interpreted disclosure off financial statements from the perspective of the residual rights of control, and advocated the information which is important, measurable and consistent with the definition of the accounting elements shall be included in the financial statements as much as possible [8]. Zhang Jinruo and Song Ying (2009) conducted research on the issue of classification and presentation of financial statement [9]. Although academia and accounting standards-setting institutions all over the world have made great efforts for the improvement of the financial statements, financial statements in the current system remains flawed, it cannot meet the needs of the information consumer well. Based on this, this paper uses the resource theory, making a clear distinction between the resources, assets and capabilities, and builds a resource-based system of financial statements.

2 The Major Defects of the Current System of Financial Statements

2.1 IASB, FASB, ASB and China's Current System of Accounting Reports

At present, national financial reports system mainly consists of balance sheet (statement of financial position), the profit and loss statement (income statement), cash flow statement, statement of comprehensive income or statement of owner's equity. IASB, FASB, ASB and China's current financial statements system is shown in Table 1.

Table 1 IASB, FASB, ASB and our current financial statements system

Standards-setting institution	IASB	FASB	ASB	China's ministry of finance
The composition of the financial statements	(a) Statement of financial position	(a) Statement of financial position	(a) Profit and loss statement	(a) Balance sheet
	(b) Statement of comprehensive income	(b) Statement of comprehensive income	(b) All have been confirmed gains and losses table	(b) Profit statement
	(c) Cash flow statement	(c) Cash flow statement	(c) Balance sheet	(c) Statement of cash flow
	(d) Notes to the financial statements	(d) Notes to the financial statements	(d) Statement of cash flow	(d) Statement of owner's equity
			(e) Notes to the financial statements	(e) Notes to the financial statements

From Table 1, we can find that the current financial statements system of IASB is the same with FASB, they both combine income statement and statement of comprehensive income to the statement of comprehensive income, while China's financial statements system is the same with ASB, setting statement of owner's equity or total recognized gains and losses table to reflect gains and losses recognized besides profit statement.

2.2 The Major Defects of the Current Financial Statements System

Due to the restriction of traditional accounting concept, the formulation of accounting standards didn't jump out the frame that takes enterprise assets as the main accounting object. So that self-generated goodwill which reflects the core competence, competitive position and competitive advantage have not yet contained in the financial statements system. As a result, Philip Morris paid $1.29 billion for Kraft Inc. in 1988, and 90 % was goodwill which didn't reflect in the traditional accounting statement. Although enterprise accounting standards which China issued in February, 2006, separated goodwill from intangible assets, the China's ministry of finance sets standard only for merger and acquisition goodwill, self-generated goodwill has still excluded from the financial statements. The most defect of the current financial statements system is that accounting information is incomplete, and it cannot reflect the influence on performance because of the value of enterprise competence (goodwill) and its change, so that contradictions between demand and supply of accounting information is serious [10].

This paper holds that the construction of financial statements system shall base on enterprise resources to make information better meet the needs of users.

3 Accounting Elements and the Accounting Equation Based on Enterprise Resources

Resource-based theory is a combination of resource-based view, competence-based view, knowledge-based view. The main point is as follows: (1) enterprise is a collection of resources; (2) the reason why enterprise profit is that it has scarce resources and product of low production cost or high differentiation; (3) the competitive advantage comes from internal not external, depended on the enterprise proprietary resources which is heterogeneity, scarce, difficult to imitate, efficient, invisibility and intellectual; (4) enterprises have continuously inner power to produce heterogeneous resources, and they can effectively use and maintain competitive advantage; (5) competence is built on the basis of knowledge, and knowledge is micro basis to create competence [11].

This paper holds that resource is equal to asset and competence. Assets and competence are important resources which exist in enterprise and can be used to create value. Li Yuju (2010) made in-depth analysis respectively from two aspects: the market and the enterprise and its interaction process and found that there is a close relationship between goodwill and competence. Goodwill is comprehensive evaluation to sustainable business performance of the enterprise, it comes from the enterprise and reflects that the enterprise adapts to development of the market. And goodwill is also the concentrated reflection of the core competence of the enterprise, and it is of great significance to reduce the risks and costs in market transaction. The conclusion is that goodwill is the external performance of competence, and competence is inner support of goodwill [12]. In this way can we realize the goal to accounting the value of resource through accounting assets and goodwill in accounting according to "resources = assets + competence" and "goodwill is a manifestation of the value of the competence". Just because of this, resource-based theory can be used for the development of accounting theory, then the above equation can be turned into "resources = assets + goodwill". According to the actual situation in China, we can add the gain and loss, goodwill to the existing accounting elements, and cancel the profit elements, and change the owner's equity (equity) into the equity elements. Thus, accounting elements include assets, goodwill, liabilities, equity, income, gain, cost and loss. The accounting equation base on resources accounting is as follows:

The value of resources = liabilities + equity
The value of resources = assets + goodwill
Equity = stockholder's equity + residual equity
Assets = liabilities + stockholder's equity
Profit = income – cost + already realized controllable gains and losses
Profit from operation = income – cost
Comprehensive income = profit + controllable gains and losses + uncontrollable gains and losses

4 The Construction of Financial Statement System That Based on Enterprise Resource

With the development of economy, the contribution of intangible resources is increasing, resulting in the needs of the disclosure of relevant information. American Association of Investment Management (AIMR, 2003) surveyed investment analysts, corporate executives and directors in the form of a questionnaire survey about the quality and importance of the company's accounting information disclosure, and the result showed that people considered the income statement, balance sheet, cash flow statement is very or extremely important accounted for 87 %, 90 % and 87 %; and goodwill information is very or extremely important accounted for 67 % [13].

According to the need of users and resource-based accounting elements and accounting equation, financial reporting system should be constituted by balance sheet, income statement, cash flow statement, resource equity, comprehensive income, goodwill index and changes of the value. Among them, the balance sheet, income statement, cash flow statement are basic statements, resource equity, comprehensive income, goodwill index and changes of the value are extensible statements, and now extensible statements can be yearly report. The new financial reporting system still retain the balance sheet, income statement, cash flow statement of the original reporting system, and add resource equity and goodwill index and changes of the value. The existing accounting recognition criteria can be used for basic statements elements: (1) Comply with the definition of the accounting elements; (2) The economic benefits which is related to the project is likely to flow into or out of the enterprise; (3) The cost or value of the project can be measured reliably. While the new recognition criteria should be developed for extension report elements: (1) Comply with the definition of the accounting elements; (2) The economic benefits which is related to the project is likely to flow into or out of the enterprise; (3) Measurability (it can be monetary measurement, it also can be non-monetary measurement) and verifiability. All statements should be reported by fair value eventually.

4.1 Resource Equity

Resource equity is the statement which reflects the component and the source of the enterprise resources. We can realize the component of the assets, goodwill, liabilities, shareholders' equity and residual equity through resource equity. Through resource equity in different periods, we can know the changes in the value of enterprise resources, so that corporate stakeholders can make the appropriate decisions.

4.1.1 The Design Ideas of Resource Equity

Changed assets into resources and increased the value of goodwill in the resource section, liabilities and equity take the place of liabilities and owners' equity, and increase the residual equity in the equity section. The specific method is to set the "goodwill" account and "residual equity" account, the value of goodwill should be confirmed by evaluation, goodwill tests are required to be performed regularly (a quarter or half a year), determine the goodwill value after change through the preparation of Goodwill Index, then prepare Resource Equity. The specific design of Resource Equity is shown in Table 2.

Table 2 Resource equity

Prepared by:					Month:	Year:	
Resource	No.	At beg of year	At end of period	Liabilities and equity	No.	At beg of year	At end of period
Total current assets				Total current liabilities			
Intangible assets				Total non-current liabilities			
Total non-current assets				Total shareholder's equity			
Total assets				Residual equity			
Goodwill				Total equity			
Total resources				Total liabilities & equity			

4.1.2 The Way of Increasing the Resource Equity

The Resource Equity this paper added is on the basis of balance sheet. Making some change on the basis of the current account: (1) increase "goodwill" and "residual interest"; (2) usual accounting goodwill index, through the certain goodwill metering method to determine the value of goodwill regularly or actual needs.

Equity is an important element of financial statements, it represents a claim of internal stakeholders on the particular accounting entity resources. The definition, recognition and measurement of equity have a direct impact on the confirmation and report of the financial position of accounting entity and the calculation and allocation of operating income. This paper argues that the equity consist of stockholders equity and residual equity. The stockholders equity can be confirmed and measured through the current confirmation metering method; the residual equity is the value implied by the enterprise capabilities, it can be confirmed and measured with the recognition and measurement of goodwill. The value of goodwill is the amount of residual interest that the enterprise possesses.

4.2 Comprehensive Income Statement

Comprehensive income statement is a report that reflects overall income status of the enterprise during a period. Through comparison of comprehensive income statement during different period, users can realize the enterprise financial performance and wealth changes. By analyzing the reasons of change, enterprise performance and management of the business performance and the future development potential of the enterprise can be evaluated [14].

Table 3 Comprehensive income statement

Prepared by:	Month:	Year:	
Item	Current month	Current year	Prior year
1. Net profit			
2. Other comprehensive income (with "—" for loss)			
The unrealized profits and losses of the securities			
The changes of profit and loss of goodwill			
3. Comprehensive Income(with "—" for loss)			
Net earnings per share			
Diluted earnings per share			
Comprehensive income per share			
Diluted comprehensive income per share			

The author deems that the current comprehensive income statement does not reflect enterprise's income completely and does not include the information about the changes of enterprise goodwill. In order to better meet the information user's demand for accounting information, the comprehensive income statement should be improved.

4.2.1 The Improvement Ideas of Comprehensive Income Statement

Increase the changes in profit and loss of goodwill on the basis of the current comprehensive income statement, and the data about the changes of goodwill is calculated according to the goodwill measure model. The comprehensive income statement is as shown in Table 3:

4.2.2 The Way of Improving Comprehensive Income Statement

In this paper, improvement of comprehensive income statement is built on the basis of the existing comprehensive income statement at home and abroad. The data about the changes of goodwill is calculated according to the goodwill measure model that the author built, and its recognition bases on the build of the goodwill index.

4.3 The Statement of Goodwill Index and the Changes of Value

4.3.1 The Design Ideas of the Statement of Goodwill Index and the Changes of Value

The statement of goodwill index and the changes of value is a statement that reflects the goodwill index of the corporate and its changes, also reflects the value of goodwill. Through comparison by the goodwill index and the change of its value during different periods, we can analyze the production and operational efficiency, the competitiveness of enterprises and the change of the ability to achieve sustainable development, and the existing problem and investment value, so that stakeholders make appropriate decisions.

According to the research of Li Yuju, goodwill comes from competence, the core element of the goodwill is sustainable business performance capabilities of the enterprise, while competence consists of comprehensive operation efficiency, industry potential and development potential [15]. Comprehensive operation efficiency reflects operational efficiency and effectiveness, it can judge by ten indicators: total sales income per capita, total sales revenue margins, net profit margin, cost-profit ratio, energy consumption per 10,000 yuan of sales income, liquidity turnover rate, net asset growth rate, digitization and network management coverage, itself reason the accident rate, authigenic accident disposal cumulative hours. Industry potential epitomizes the company's products, the level of services and its market position, it can judge by six indicators: leading products market share and its sales growth rate, new products and new market sales to total sales revenue, assets capital ratio, the new branding expenses to total sales revenue, complaints changes from social and consumer. Development potential mainly reflects the ability to achieve long-term stable development, it can be measured by 10 indicators: equipment investment accounted for proportion of sales revenue, expense for development of strategy research accounts for proportion of sales revenue, new research and development expense accounts for the proportion of sales revenue, the number of personnel engaged in research and development directly, new patents, the number of large-scale production of new products, new increased staff training expenses, full average years of education, marketing and R & D personnel accounted for the proportion of all employees, employee incentive expenses accounted for proportion of the total wage expenditure. Then the statement of goodwill index and the changes of value can be designed as shown in Table 4.

4.3.2 The Way of Increasing the Statement of Goodwill Index and the Changes of Value

According to the research of Li Yuju (2010), the author established the index system which composed of 26 indicators for the three competences according to the principle of objective, quantitative, data can be easy to get and no overlapping, and build goodwill index econometric models to determine the goodwill index and the value of goodwill, then prepare the statement of goodwill index and the changes of value.

With the perfection of information technology, the breakthrough of measurement technology and method and the improvement of financial personnel diathesis and the ability of information users to read the statements, the income statement and the comprehensive income statement can be combined to the comprehensive income statement, and resource equity replace the balance sheet (statement of financial position).

Table 4 The statement of goodwill index and the changes of value

Month: Year					
		Pre-index		Index changes	
Item	Current index	The same period last year	The base period	Year-on-year growth	The growth than in the base period
Comprehensive operation efficiency (E)					
Industry potential (P)					
Development potential (Q)					
Goodwill index (G)					
The value of goodwill (S)					

5 Conclusion

1. Financial statements are important carrier to output accounting information. Financial reporting system is not static, but it is improved and perfect based on the development of social economic and demand of users.
2. The current financial reporting system is built on the basis of assets. It is unable to provide enterprise value, complete comprehensive income information and the information of enterprise capabilities that reflect the competitive advantage and the changes of wealth. It is not enough to meet the development of social economic and demand for accounting information users. The contradiction between supply and demand of accounting information is obvious.
3. The financial statements system based on enterprise resources should be built to solve the contradiction between supply and demand of accounting information, that is to increase resources equity, comprehensive income statement, the statement of goodwill index and the changes of value on the basis of the existing reporting system. The elements of basic statements and extensible statements use different recognition criteria and measurement methods.
4. The construction of financial statements system which based on enterprise resources, must based on the development of traditional accounting theory, the construction of the new financial accounting conceptual framework, and confirmation and measurement of goodwill.

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Evaluation of Financial Performance on Oil Industry Central Enterprises Based on Principal Component Factor Analysis

Yan-fang Gao, Ai-ping Gao, and Ning Shi

Abstract The three major oil central enterprises of China are elected in FORTUNE 500. Their rankings are respectively 5th, 6th and 101st in 2012. However, ranking in FORTUNE 500 is based on only one indicator, which is operating income. Although the three companies have their Annual Financial Reports, we can't compare their financial performance. Therefore, we constructed a set of financial performance evaluation index system, and evaluate their financial performance with the method of principal component factor analysis.

Keywords Evaluation • Financial performance • Oil central enterprises • Principal component

Sinopec Group (SG), China National Petroleum Corporation (CNPC) and China National Offshore Oil Corporation (CNOOC) are the three oil central enterprises of China. Their rankings in FORTUNE 500 are 5th, 6th and 101st in 2012. The rank is based on business income. We try to create a set of financial performance evaluation index system, and assess the financial performance of the three oil central enterprises with the method of principal component factor analysis.

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1 Choice of Evaluation Methods and Building of Index System

1.1 Choice of Evaluation Methods

We use the method of principal component factor analysis, this method is able to calculate the composite score objectively [1].

1. The theory of principal component factor analysis

The method of principal component factor analysis aims to use the ideas of dimensionality reduction, transform the multiple indicators into a few indicators [2].

2. The model of principal component factor analysis

$$
\begin{aligned}
&F_1 = a_{11}ZX_1 + a_{21}ZX_2 + \ldots\ldots a_{p1}ZX_p \\
&F_2 = a_{12}ZX_1 + a_{22}ZX_2 + \ldots\ldots a_{p2}ZX_p \\
&\ldots \\
&F_p = a_{1m}ZX_1 + a_{2m}ZX_2 + \ldots\ldots a_{pm}ZX_p
\end{aligned}
$$

a_{1i}, a_{2i}, …… a_{pi}, ($i = 1, 2, \ldots m$) are eigenvectors corresponding to the eigenvalue which are solution of X covariance matrix.

ZX_1, ZX_2, …… ZX_p are the value of the normalized original variable.

1.2 The Construction of the Indicator System

According to the Central four ministries developed jointly by the <state-owned capital and performance evaluation rules >1999 and the State Council issued <central enterprise comprehensive performance evaluation of the implementation of the rules >2006, we selected 4 one-class indexes, 14 secondary indexes. Then build oil central enterprises financial performance evaluation index system (Table 1) [3].

2 Empirical Analysis

2.1 Data Collection and Processing

According to the 2011 annual financial report, we obtained 14 indicator values as in Table 2 (CNOOC annual financial report did not reflect main business income and main business cost, so we use operating income replace main business income and operating cost replace main business cost). Calculating with SPSS [4].

Table 1 Financial performance evaluation index system of oil central enterprises

The first class index	The second class index	Index code
Profitability	Rate of return on net assets	X1
	Sales profit rate	X2
	Surplus cash coverage ratio	X3
	Cost profit rate	X4
	Rate of return on capital	X5
Asset quality	Turnover of total assets	X6
	Assets cash recovery rate	X7
	Turnover of current assets	X8
Debt risk	Asset liability ratio	X9
	Quick assets ratio	X10
	Cash current liabilities ratio	X11
Business growth	Sales growth rate	X12
	Sales profit growth rate	X13
	Total assets growth rate	X14

Table 2 Financial index of three major oil central enterprises

Financial indexes	CNPC	SG	CNOOC
X1	13.95 %	15.98 %	20.40 %
X2	14.54 %	8.88 %	25.17 %
X3	1.82	1.84	0.94
X4	10.11 %	4.29 %	29.53 %
X5	49.10 %	66.15 %	64.86 %
X6	1.12	2.37	0.73
X7	16.24 %	14.29 %	20.19 %
X8	5.93	8.68	2.76
X9	43.54 %	54.91 %	36.12 %
X10	36.28 %	28.94 %	113.92 %
X11	51.81 %	35.23 %	99.73 %
X12	36.74 %	30.97 %	37.61 %
X13	0.94 %	1.68 %	16.39 %
X14	15.77 %	14.68 %	16.42 %

2.2 Select Main Components and Construct the Comprehensive Evaluation Function

Seen from Table 3, the first two factors cumulative variance contribution rate has reached 100 and feature values were 11.586 and 2.414 which are more than 1, so the two public factors as the initial factors (F1 and F2), its factor loading matrix as shown in Table 4. In Fig. 1, it tells that from the second public factor, curve gradient becomes relatively flat, so extract two main factors are more suitable. Table 5 is a rotated factor loading matrix. From the view of joint degree of factors, almost all information of 14 variables can be explained by the two public factors [5].

Table 3 Total variance explained

	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.586	82.757	82.757	11.586	82.757	82.757	8.332	59.514	59.514
2	−2.414	17.243	100.000	2.414	17.243	100.000	5.668	40.486	100.000
3	−7.192E-16	5.137E-15	100.000						
4	−4.071E-16	2.908E-15	100.000						
5	−2.570E-16	1.836E-15	100.000						
6	−1.716E-16	1.226E-15	100.000						
7	−8.211E-17	5.865E-16	100.000						
8	−2.591E-17	1.850E-16	100.000						
9	−6.394E-18	−4.567E-17	100.000						
10	−1.390E-16	−9.932E-16	100.000						
11	−1.963E-16	−1.402E-15	100.000						
12	−2.689E-16	−1.921E-15	100.000						
13	−4.244E-16	−3.032E-15	100.000						
14	−6.467E-16	−4.619E-15	100.000						

Extraction method: principal component analysis

Table 4 Component matrix[a]

	Component	
	1	2
X1	.801	.599
X2	1.000	−020
X3	−.952	−.305
X4	.994	.107
X5	.126	.992
X6	−.883	.469
X7	1.000	−.001
X8	−.988	.153
X9	−.951	.310
X10	.969	.249
X11	.997	.079
X12	.827	−.562
X13	.932	.363
X14	.943	−.333

Extraction method: principal component analysis
[a]Two components extracted

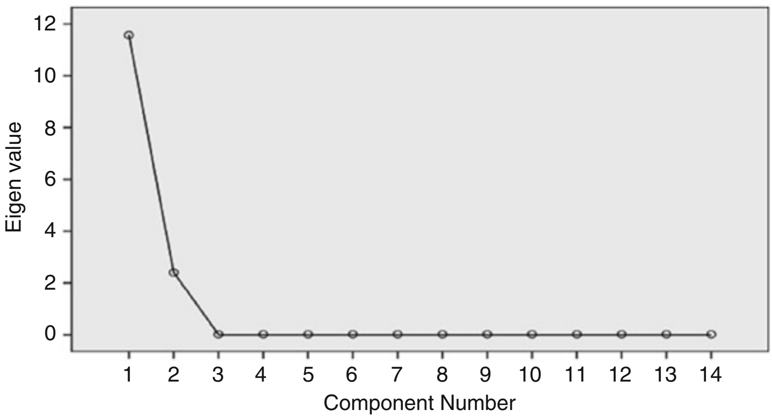

Fig. 1 Scree plot

As you can see from Table 5, X12 and X14 in public factor F1 has a larger load, so we can think F1 is reflected in business growth capacity factor; X1 and X5 in public factor F2 has a larger load, so F2 can be regarded as the profitability factor [6].

According to the Component Score Coefficient Matrix as show in Table 6, we can obtain principal component model:

Table 5 Rotated component matrix[a]

	Component	
	1	2
X1	.287	.958
X2	.815	.580
X3	−.583	−.812
X4	.735	.678
X5	−.490	.872
X6	−.989	−.149
X7	.804	.595
X8	−.885	−.466
X9	−.948	−.317
X10	.630	.777
X11	.754	.657
X12	.999	.041
X13	.532	.847
X14	.956	.294

Extraction method: principal component analysis
Rotation method: Varimax with Kaiser normalization
[a]Rotation converged in three iterations

Table 6 Component score coefficient matrix

	Component	
	1	2
X1	−.092	.240
X2	.074	.045
X3	.009	−.150
X4	.043	.087
X5	−.236	.337
X6	−.177	.111
X7	.070	.051
X8	−.106	.000
X9	−.142	.054
X10	.006	.133
X11	.050	.078
X12	.196	−.145
X13	−.025	.169
X14	.147	−.062

$$
\begin{aligned}
F1 = {} & -0.092^{*}ZX1 + 0.074^{*}ZX2 + 0.009^{*}ZX3 \\
& + 0.043^{*}ZX4 - 0.236^{*}ZX5 - 0.177^{*}ZX6 + 0.07^{*}ZX7 \\
& - 0.106^{*}ZX8 - 0.142^{*}ZX9 + 0.006^{*}ZX10 + 0.05^{*}ZX11 \\
& + 0.196^{*}ZX12 - 0.025^{*}ZX13 + 0.147^{*}ZX14
\end{aligned}
$$

Table 7 Evaluation of financial performance

	Component score				Comprehensive score	
Enterprise	F1	Ranking	F2	Ranking	F	Ranking
CNPC	−0.8515	2	0.1246	3	−0.4563	2
SG	−1.4522	3	0.3078	2	−0.7395	3
CNOOC	−0.4405	1	0.4667	1	−0.0732	1

$$\begin{aligned} F2 = {} & 0.24^{*}ZX1 + 0.045^{*}ZX2 - 0.15^{*}ZX3 + 0.087^{*}ZX4 \\ & + 0.337^{*}ZX5 + 0.111^{*}ZX6 + 0.051^{*}ZX7 + 0^{*}ZX8 \\ & + 0.054^{*}ZX9 + 0.133^{*}ZX10 + 0.078^{*}ZX11 \\ & - 0.145^{*}ZX12 + 0.169^{*}ZX13 - 0.062^{*}ZX14 \end{aligned}$$

The variance contribution rate reflects the importance of principal components, therefore, regard the variance contribution rate (two principal component's contribution rate) as the principal components weights to carry on comprehensive evaluation, then we can build the evaluation model:

$$F = 0.5951F1 + 0.4049F2$$

By using the above evaluation model, we can obtain the financial performance evaluation of three big Petroleum central enterprises (Table 7)

3 Conclusion and Discussion

Components score Listed in Table 7 reflects financial performance status of three big Petroleum central enterprises. Generally, CNOOC's financial performance status is the best, CNPC is the second, SG is the final [7].

The result is in accordance with the financial performance realization status of the three big companies. So it proves that using the method of principal component analysis is of great value. But in the index quantification process, it only selects portion statistical data, some qualitative indexes are not properly reflected; so in the future studies, we can adopt some methods that can quantify the qualitative indexes, which makes the evaluation results more objective and comprehensive [8].

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Simulation and Comparison of Equipment Maintenance Strategies—A Blast Furnace Belt Conveyor Example

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Abstract In recent years, a number of industrial accidents took place in turns, resulting in enormous economic loss, personnel lives loss, and environmental disasters. Industrial accidents arise mostly from equipment failures. Traditional time-based maintenance appears have reached its limit to prevent more accidents. New strategies turn to condition-based maintenance (CBM), which continuously monitors equipment so that failures can be detected just in time. The new strategies can be expensive and difficult to implement in current equipment. Under increasing cost pressure, enterprise has difficulties to evaluate the effectiveness of the strategies. This paper presents a reliability simulation to evaluate and compare different maintenance strategies, from both cost and productivity perspectives. A blast furnace belt conveyor is used as a demonstration example. In addition, experiment design and multiple comparison procedures are used to give statistical analysis. It is expected this research can help industries evaluate and select an appropriate maintenance strategy to further reduce future equipment failures and associated losses.

Keywords Reliability simulation • Time based maintenance • Condition based maintenance (CBM)

1 Introduction

Manufacturing is the foundation of industries. Both conventional and high-tech manufacturing industries use a large quantity of equipment to produce commodities. Under sharp productivity and utilization competitions, most equipment runs 24 h

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Fig. 1 A petroleum refinery plant fire accident

a day. The mechanic wear and tear from incessant usage results in inevitable equipment failures. Mild failures causes defect products, while serious failures result in enormous economic loss, personnel lives loss, and environmental disasters.

In recent years, a number of industrial accidents took place in turns, highlighting the importance of equipment maintenance. Figure 1 shows a fire accident of a petroleum refinery plant. Although investigations and improvements have been followed after each accident, it appears accident does not stop happening, even the inspection period has been continually shortened. Traditional time-based maintenance appears have reached its limit to prevent more accidents [1]. To solve the problem, new condition-based maintenance has been developed, such as the techniques using shock pulse method (SPM) and vibration detection [1, 2]. The condition-based maintenance has shown a great potential to further reduce accidents. However, since enterprises are pressured to cut their costs [1, 3], decision makers hesitate to adopt the new maintenance strategy.

This paper will use system simulation to evaluate various maintenance strategies to compare their effectiveness. Simulation has been well known for its "what-if analysis" capability, and will be used in this paper to provide performance assessments. In addition, statistical procedures will be used to design experiments and compare maintenance strategies to provide results interpretation. The objective of the paper is to a provide industries a convenient way to envision the differences among maintenance strategies and select an appropriate one. We summarize maintenance strategies in Sect. 2. Section 3 presents how to build models for reliability simulation. A blast furnace belt conveyor will be used as an example. Section 4 demonstrates the experiment design and the analysis of simulated results using multiple comparison procedures. Conclusions will be given in Sect. 5.

2 Maintenance Strategies

Due to the serious damage of equipment failures, equipment maintenance has been a critical issue to almost all industries. Over the years, the mind-set of maintenance has evolved from *reactive* to *planned/scheduled, and then* to *condition-based maintenance* [4]. There are four major maintenance strategies, as summarized in the following:

2.1 Reactive or Corrective Maintenance [5]

Reactive maintenance takes a run-to-failure approach. No maintenance is scheduled and no condition assessment is conducted. Correction is done upon failure. The strategy is usually adopted for non-critical equipment, and the reliability can be hardly controlled.

2.2 Time-Based or Preventive Maintenance [3, 6]

The strategy pre-schedules periodic maintenance to do repairs or replacements prior to failures. The maintenance is usually time-based and the frequency is based on historical data. Since failures take place stochastically, time-based maintenance cannot prevent every failure, but to prolong the time spans between failures [7]. That is, failures still occur under this strategy. In response to this problem, the maintenance frequency tends to be shorter and shorter to prolong the time between failures. Hence, the cost of the strategy can be high.

2.3 Predictive Maintenance [6]

Many failures can be monitored and predicted with respect to a certain parameters. Those parameters usually exhibit statistical patterns. Predictive maintenance is to monitor the parameters periodically to issue early warnings of degradation or failure. For instance, predictive maintenance can be based on bearing heat signature, lubricant condition, or rotating vibration. Since the parameters are only monitored periodically, failures can happen in between periods, resulting in a similar dilemma as preventive maintenance.

2.4 Condition-Based or Just-In-Time Maintenance [3, 6]

Similar to predictive maintenance, condition-cased maintenance (CBM) monitors the system conditions that are critical to failures. The monitor is done continuously and in real time such that equipment problems can be detected just-in-time [1]. This strategy is relatively new. Most of the equipment that could use condition-based maintenance is not instrumented with sensors, limiting the adoption of the CBM.

The strategies above have different implementation difficulties [8]: Reactive maintenance has reliability hardly controlled. Either preventive or predictive maintenance has their limits to prevent failures. In contrast, CBM is effective to prevent failures, but the implementation is difficult and expensive. Facing the reliability and safety requirements, enterprises are also increasingly pressured to reduce their costs. How to evaluate maintenance strategies to consider the tradeoff between reliability and cost has been a dilemma to enterprise decision makers [8]. In the next section, we present a scheme of reliability simulation for evaluating maintenance strategies.

3 Reliability Simulation

System simulation is the technique that can abstract the features of a dynamic system by experimenting on its process models. The models mimic system operations and statistical characteristics to reproduce as real as system behaviors. Therefore, simulation is widely used as a tool to analyze *what-if* decisions. This section demonstrates how to use simulation to evaluate maintenance strategies. To begin with, we introduce a blast furnace belt conveyor for the demonstration purpose.

3.1 Blast Furnace Belt Conveyor

Blast furnace is the equipment for smelting to produce iron. In a blast furnace, raw materials such as ore and flux are continuously supplied through a belt conveyor. The conveyor is nearly 8,000 m long, and about four or five stories high as shown in Fig. 2. Its repair is extremely difficult, especially on the top above the furnace, where the combustion and high temperature result in a hypoxic state. Once the conveyor fails to deliver materials, it will cause the shutdown of the furnace. The cost from this is measured as high as 10,000 NT dollars per minute. And the loss of supply shortage to its downstream industries is immeasurable. The maintenance strategy of the belt conveyor has been a critical decision to the steel smelting industry. We will take the belt conveyor as an example to demonstrate how to build its reliability simulation model, and how to experiment the model to evaluate different maintenance strategies. Figure 3 presents the structure of a belt conveyor, which consists of a number of subsystems, and each subsystem consists of a number of components.

Fig. 2 Belt conveyor in a blast furnace

3.2 Simulation Model and Input Factors

To build simulation models for the belt conveyor, we use SIMPROCESS [9], which is a hierarchical and integrated process simulator. The model has three hierarchical layers as shown in Fig. 4, corresponding to the structure of Fig. 3. The three layers are main system layer, subsystem layer, and component layer. We describe each layer from the bottom up.

The bottom layer is the component layer, which models the life cycles of a component. A life cycle starts from a normal condition. After a random period of time, the component steps in an initial damage state, resulting from operations wearing. The random period of time can be sampled from various probability distributions, with an average known as MTBF (mean time between failures). This paper uses normal distributions to sample the random times. The cycle is followed by another random period of time to step in a failure state. This period of time models the time span from initial damage to breakdown, if no preventive or predictive maintenance is performed. When a component fails, the cycle goes into a repair state. It takes the third period of time to fix the component. This period models the interval consumed by materials preparation and repairs. Once the component is fixed, it resumes a normal condition and a new cycle starts. In addition to the time perspective, the resources consumed in the process and their costs are also built in the model. The resources include the raw materials and maintenance technicians. The crude simulation consists of iterative life cycles. Performance statistics are collected in the simulation and are used to estimate the component reliability and associated costs. More importantly, different maintenance strategies can be embedded in the model to compare their effectiveness. Two specific strategies are constructed in the model: time-based maintenance and condition-based maintenance, which are described in the following.

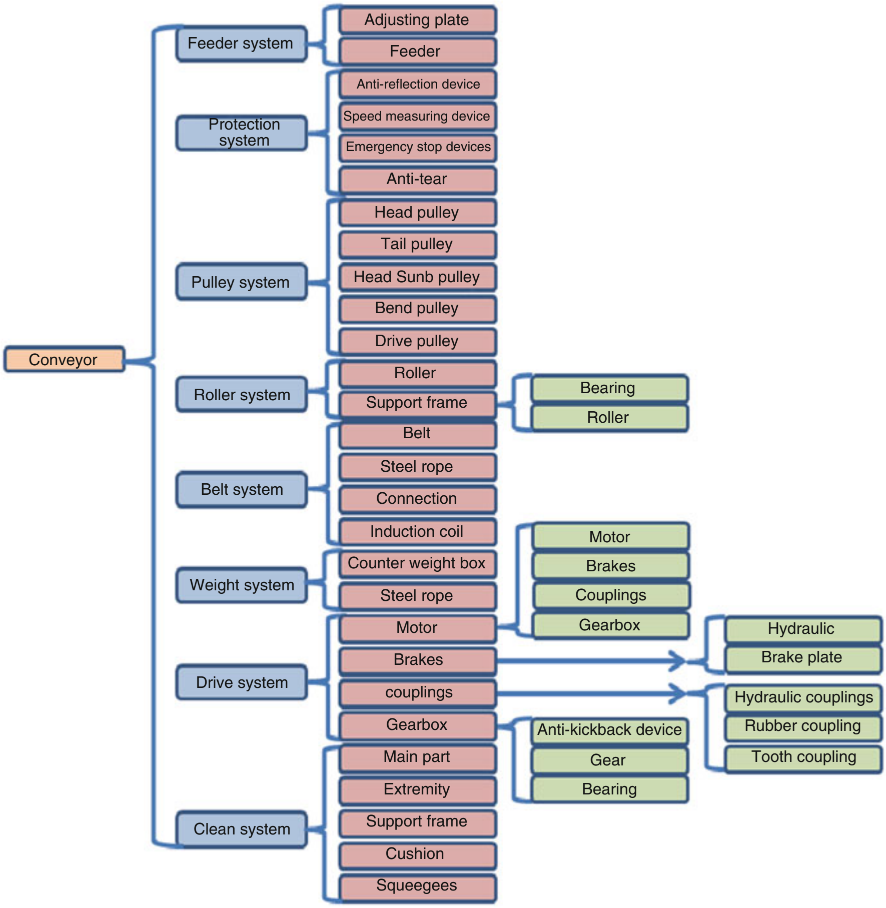


Fig. 3 The hierarchical structure of a belt conveyor

Time-based maintenance is built in the model as repeated processes in parallel with the component life cycles. Interactions take place between the two cycles in such a way that the maintenance will affect the component life cycles: If a regular-scheduled maintenance runs into an initial damage, a repair is prescribed to restore the component to a normal condition, thus skipping the failure and repair stages. Since a regular maintenance may or may not detect early damages, an input parameter can be assigned to control the probability of successful detection. The maintenance frequency is also an input parameter, which can be optimized by using an optimization module of SIMPROCESS.

In the other way, condition-based maintenance is built within the component life cycle. Since CBM monitors a component continuously, an initial damage can be quickly detected. Just in time replacement or repair can restore the component to a

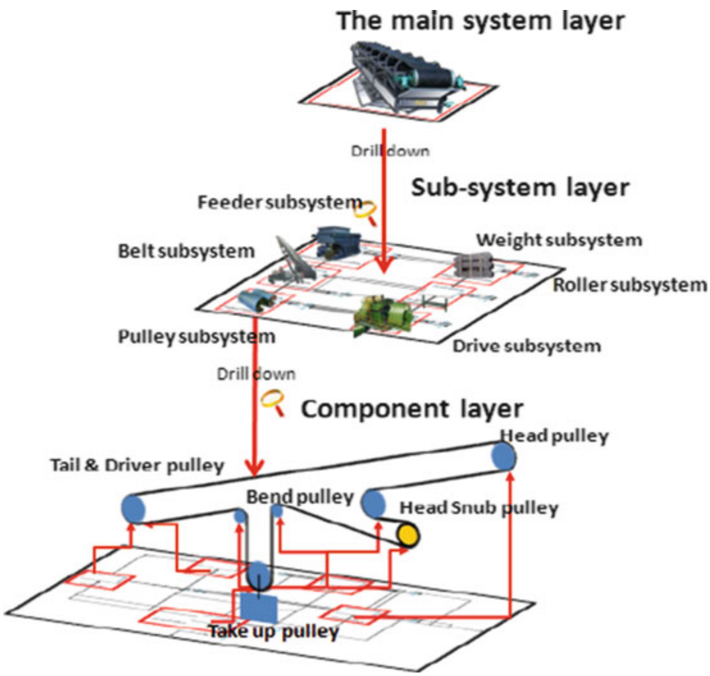


Fig. 4 The hierarchical simulation model of blast furnace belt conveyor

normal condition and skip the failure stage. Since CBM may not 100 % detect an initial damage, an input parameter is also provided to control the probability.

Each component in the model can selectively use CBM strategy, in conjunction with regular time-based maintenance. Various statistics are summarized in simulation to provide decision makers multiple evaluation perspectives.

The middle layer of the simulation model is subsystem layer, as shown in the middle part of Fig. 4. This layer models the interactions among the components of a subsystem. For instance, there are five components in a pulley subsystem: head pulley, bend pulley, drive pulley, head snub pulley, and tail pulley. When a component fails, notices will be sent to all other components and subsystems to hold and wait until the failing component is repaired. This interaction is done by using preemptions; that is, the cycles of all working component will be preempted by a failing component. Similarly, once a failing component is fixed, notices will be sent to resume the process of all preempted component.

The top layer of the simulation model is main system layer, as shown in the top part of Fig. 4. This layer models the interactions among subsystems. There are six subsystems in the model, including a belt subsystem, a feeder subsystem, a roller subsystem, a pulley subsystem, a drive subsystem, and a weighting subsystem. The top layer can drill down to each of the six subsystems, and the subsystem model can drill down to its components. Preemption is again used to implement the interactions.

Count Statistics	Regular maintain count
	Initial damage maintain count
	Preventive maintain
	Condition maintain
	Unplanned repair maintain count
Cost Statistics	Regular maintain cost
	Initial damage maintain cost
	Unplanned repair maintain cost
Utilization Statistics	Simulation time
	Up time
	Up time rate
	Down time
Resources Statistics	Regular Maintain Technician utilization
	Preventive maintain Technician utilization
	Repair Technician utilization

Fig. 5 Key performance output

All the three layers work together to simulate the operation states under time-based or condition-based maintenance strategies. The input factors of the model are imported from an external file for flexibility. There are 12 factors for *each* component, as listed in the following:

1. mean time from normal state to initial damage
2. mean time from initial damage to failure
3. regular maintenance time period
4. mean time of a regular maintenance
5. mean time of a maintenance if an initial damage is detected
6. probability that an initial damage can be detected in a regular maintenance
7. mean time of a failure repair
8. cost of a failure repair
9. cost of an initial damage fix
10. cost of a regular maintenance
11. probability that an initial damage can be detected by a CBM sensor
12. average lead time to repair a failure

Part of the factors is basic data, and the others can be treated as decision variables and can be optimized. In the next section, we introduce the output of the simulation.

3.3 Key Performance Output

The simulation model runs with different combination of input factors to collect performance statistics. In each replication, the run length is 2 years. Different performance is collected with respect to each layer of the model. There are four perspectives of performance collected as shown in Fig. 5. The first perspective is count statistics, such as failure counts, hold counts, and maintenance counts. The second perspective is cost statistics, such as failure cost, regular maintain cost, and initial damage maintain cost. The third perspective is productivity statistics, such as uptime percentage and average uptime. The fourth perspective is resources' utilization, such as the utilization of maintain engineers and repair technicians. Each layer of the model collects statistics associated with that layer, so that the performance can be evaluated from both micro and overall angles. By all means, the simulation provides decision makers quantitative statistics to visualize the performance of different strategies.

4 Experiment Design and Multiple Comparisons

The purpose of simulation is to evaluate maintenance strategies. To obtain meaningful interpretations, statistical procedures need to be used in experiment design and results analysis. We make up six maintenance strategies, as listed in Table 1, to demonstrate the comparisons. Dummy data is used in the sense we only intend to demonstrate the evaluation procedure. Strategy A is a purely time-based maintenance; only periodic maintenance is scheduled for each component and subsystem. The other four strategies are various mixtures of time-based and condition-based maintenance; the difference is in the number of components using CBM. Strategy B has only one CBM component, while strategy F has 5 CBM components. The strategies are selected for comparisons from cost and productivity.

Because of the random nature in simulation, each strategy will run 30 independent replications to get random samples. A conventional one-way model is assumed for the simulated results:

$$Y_{ij} = \theta_i + \varepsilon_{ij}, i = 1, 2, \ldots, 6, j = 1, 2, \ldots, 30$$

where Y_{ij} is the j-th simulated performance of strategy i; θ_i is the expected performance of strategy i, and θ can be any performance as listed in Fig. 5; and ε_{ij} is a random noise with an expected value 0 and a common variance. Experiments are conducted according to the design. Part of the numerical results and bar charts with respect to different performance are presented in Fig. 6.

Table 1 Maintenance strategies for comparisons

Strategies	CBM maintenance components
A	Pure time-based maintenance (no CBM component)
B	Head pulley
C	Head pulley + drive pulley
D	Head pulley + drive pulley + bend pulley
E	Head pulley + drive pulley + bend pulley + nose pulley
F	Head pulley + drive pulley + bend pulley + nose pulley + tail pulley

Conveyor											
System Item	Plan A	Plan B	Difference	Plan C	Difference	Plan D	Difference	Plan E	Difference	Plan F	Difference
Regular maintain count	69.93	72.47	2.53	76.30	6.37	78.50	8.57	78.57	8.63	81.40	11.47
Initial damage maintain count	0.23	2.00	1.77	3.73	3.50	5.97	5.73	8.63	8.40	10.87	10.63
Condition maintain	[redacted]	1.87	1.87	3.47	3.47	5.53	5.53	8.47	8.47	10.80	10.80
Preventive maintain	0.23	0.13	0.10	0.27	0.03	0.43	0.20	0.17	0.07	0.07	0.17
Unplanned repair maintain count	19.77	18.00	1.77	16.37	3.40	14.80	4.97	13.43	6.33	11.97	7.80
Simulation time	8760.00	8760.00	0.00	8760.00	0.00	8760.00	0.00	8760.00	0.00	8760.00	0.00
Up time	5291.87	5562.17	270.30	5801.03	509.16	5990.19	698.32	6120.55	828.68	6305.60	1013.73
Down time (hours)	3468.13	3197.83	270.30	2958.97	509.16	2769.81	698.32	2639.45	828.68	2454.40	1013.73
Up time %	60.41	63.50	308.56%	66.22	581.24%	68.38	797.17%	69.87	945.98%	71.98	1157.23%
Regular maintain cost	69933.33	72466.67	2533.33	76300.00	6366.67	78500.00	8566.67	78566.67	8633.33	81400.00	11466.67
Initial damage maintain cost	2333.33	20000.00	17666.67	37333.33	35000.00	59666.67	57333.33	86333.33	84000.00	108666.67	106333.33
Unplanned repair maintain cost	1976666.67	1800000.00	176666.67	1636666.67	340000.00	1480000.00	496666.67	1343333.33	633333.33	1196666.67	780000.00
Total cost	2048933.33	1892466.67	156466.67	1750300.00	298633.33	1618166.67	430766.67	1508233.33	540700.00	1386733.33	662200.00
Regular maintain technician utilization	0.81	0.84	0.03	0.88	0.07	0.90	0.10	0.92	0.11	0.95	0.15
Preventive maintain technician utilzation	0.04	0.20	0.16	0.35	0.31	0.50	0.47	0.64	0.60	0.79	0.76

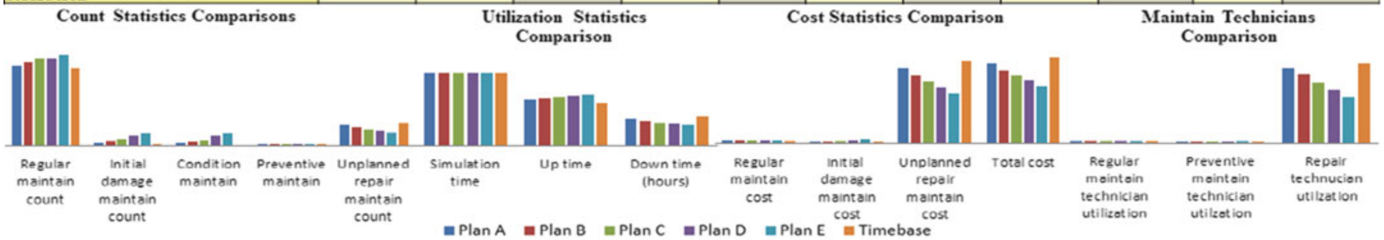


Fig. 6 Example simulation result

Row—Col	Strategies	A	B	C	D	E
Lower limit		-211629				
Center	B	-156467				
Upper limit		-101304				
Lower limit		-353796	-197329			
Center	C	-298633	-142167			
Upper limit		-243471	-87004			
Lower limit		-485929	-329462	-187296		
Center	D	-430767	-274300	-132133		
Upper limit		-375604	-219138	-76971		
Lower limit		-595862	-439396	-297229	-165096	
Center	E	-540700	-384233	-242067	-109933	
Upper limit		-485538	-329071	-186904	-54771	
Lower limit		-717362	-560896	-418729	-286596	-176662
Center	F	-662200	-505733	-363567	-231433	-121500
Upper limit		-607038	-450571	-308404	-176271	-66338

Fig. 7 MCA example results

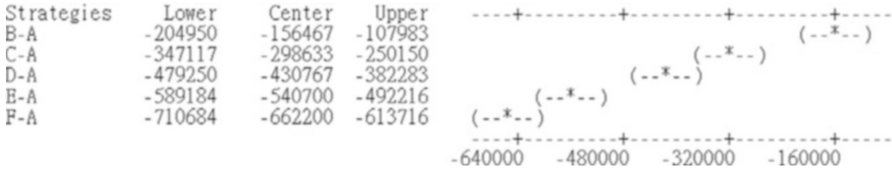
```
Strategies    Lower    Center   Upper   -------+---------+---------+---------+--
A-Best            0    662200  705237          (------------------------*-)
B-Best            0    505733  548770          (------------------*-)
C-Best            0    363567  406604          (--------------*)
D-Best            0    231433  274470          (--------*-)
E-Best            0    121500  164537          (---*-)
F-Best      -164537   -121500       0   (-*----)
                                        -------+---------+---------+---------+--
                                               0    250000    500000    750000
```

Fig. 8 MCB example results

To analyze whether there are significant differences among the six strategies, three multiple comparison procedures are used: all-pairwise comparisons, multiple comparisons with the best, and multiple comparisons with a control, which are described in the following.

All-pairwise comparison (MCA) [10] constructs the simultaneous confidence intervals for $\theta_i - \theta_j, \forall\, i \neq j$ with an overall error rate controlled. Multiple comparisons with the best (MCB) [11] constructs the simultaneous confidence intervals for $\theta_i - \theta^*, \forall\, i$, where θ^* refers to the performance of the best but *unknown* strategy. Multiple comparisons with a control (MCC) [12] constructs the simultaneous confidence intervals for $\theta_i - \theta_A, \forall\, i \neq \mathrm{A}$. Figures 7, 8, and 9 show the example results respectively.

Decision makers can distinguish among the six strategies either a unique or a group of best strategies by investigating the confidence intervals. For instance, there are $C_{6,2} = 15$ pairwise intervals constructed by MCA, as shown in Fig. 7. Strategy F is clearly the best in that all the *cost difference* between strategy F and any other strategy has a negative upper confidence limit, implying strategy F cost is



Strategies	Lower	Center	Upper
B-A	-204950	-156467	-107983
C-A	-347117	-298633	-250150
D-A	-479250	-430767	-382283
E-A	-589184	-540700	-492216
F-A	-710684	-662200	-613716

Fig. 9 MCC example results

significantly lower. And there are 6 confidence intervals constructed by MCB, as shown in Fig. 8. Strategy F can be identified as the best in that the cost difference between strategy F and the best strategy has an upper limit 0. And there are five confidence intervals constructed by MCC, as show in Fig. 9. Clearly the cost of each five condition-based strategies is significantly lower than time-based maintenance. Decision makers can conveniently select a strategy based on these statistics.

5 Conclusion

Equipment maintenance has been a critical issue to manufacturing industries. However, it is difficult for industries to choose an appropriate maintenance strategy. This paper presents a scheme to build reliability simulation models to compare maintenance strategies, from cost and productivity perspectives. A blast furnace belt conveyor is given as a demonstration example. In addition, experiment design and multiple comparison procedures are used to give statistical analysis. It is expected this research can help industries evaluate and select an appropriate maintenance strategy to reduce future equipment failures and associated losses.

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Starbucks Service Quality Provided by Decision-Making Trial and Evaluation Laboratory Explored Customers' Perception

Kuang-Tai Liu and Rong-Zhen Huang

Abstract Consumers' requirement is not only merchandise but happy purchase experiences. An individual experiences an emotion connected to merchandise, service, brand, commercial, human, or idea via interaction and memorable experiences which is experiential marketing contrast to traditional marketing. Experiential marketing designed for technology age emphasizes the fantasies, fun, entertainment, fashion and excitement of buyers with whole purchasing process. Starbucks sold its attractive atmosphere, the interior detail, the third space and quaint fashion such as its blackboard menus, jazz music, and counter designs- all perceived as part of the art, aesthetics, and humanities to its customers in its coffeehouse. However, customers' evaluation of service quality provided is often a multiple criteria decision-making problem. This research applies Schmitt's experiential marketing framework by decision-making trail and evaluation laboratory method to understand what Starbucks affectionate appeals or touchy-feely, is visceral to sell an experience that connects with consumers' psyche and life-style from mental context perspective. Meanwhile, this study delineates the causal relations among these service factors in the model using decision making trial and evaluation laboratory mathematical model and determines their effects on each other. Some suggestions and strategies will be provided the interrelations among those experiential factors.

Keywords Decision making trial and evaluation laboratory • Experiential marketing

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1 Introduction

1.1 Motivation, Purpose and Question

Starbucks brilliant twin-tailed Siren green logo has transmitted a sense of a special experience to millions of customers in its more than 19,000 coffeehouses by a unique interaction beyond coffee between its baristas and customers themselves within Proust scenario or existentialism context. Schultz, Starbucks CEO, made not only high quality coffee, but friendly embraced diversity valued the potential human communication in a place away from both home and office, but still transferred the intimacy of a good neighborhood relationship beyond perfectly made beverage. The author and professor Leo Buscaglia, also known as Dr Love, put it, "Too often underestimate the power of a touch, a smile, a kind word, a listening, an honest compliment, or the smallest act of caring, all of which have the potential to turn a life around" [1]. All attentions to detail reflect not only Starbucks' quality and reliability as its brand, but maximize the fun, fashion, fantasy, and excitement of the coffee buying experience.

Pine and Gilmore said successful experiences are unique, memorable and retainable over time beyond the ordinary customers' experience [2]. Because customers usually have short attention spans, the best marketing campaigns should make an immediate and surprising impact and hold the attention of potential customers [2]. Procter and Gamble strengthens its detergent cleaners or the whitener in its toothpaste but Singapore Airline campaign says nothing mundane; McDonald had playgrounds for fun to its restaurants to sell more than just "happy" meals for children. Holbrook suggests that in the context of consumption situations, a marketing campaign must be a synthesis of not only advertisement or packaging campaigns, but must understand the customer's priority of experiential satisfaction [3]. This study main purpose discusses what Starbucks service affectionate appeals or touchy-feely, is visceral to sell an experience that connects with consumers' psyche and life-style from mental context perspective. Meanwhile, the question in this research is which service quality provided are the most important perceived by Starbucks' customers?

2 Literature Review

2.1 Customers Experience

Dewey stated that experience is marketed by expectation, emotional involvement over time and involves a unique activity from the ordinary [4]. Schmitt stated that experiences provided sensory, emotional, thinking, behavioral and related values based hedonistic perspective [5]. Sheth proposed that three variables construct customer experiences: stimulus variable- perceiving sensory and information, context variable- influenced by the context of the stimulus, and situational variable- perceptions are influenced by individual prior experience with a particular product or service [6]. Gupta and Vajic described customer experience as interactions with different factors of a context offered by the service providers [7]. Each unique satisfying customer experience is specific to a customer, at a specific moment and place, during a specific event; factors that constrain the managerial planning and controlling function [4].

Generally consumers' decisions can be described as rational as to circumstances, but emotional as to the desire for a particular product [6]. Maslow's Need-Hierarchy theory realized that when humans' situations improved, their motivational emphasis and rational need varied. Thus, the study of consumer behavior evolved from an early focus on rational choice (classical decision theory) to an emphasis on obviously irrational buying behavior (motivation based research) [6]. Emotions are significant to consumption and a key role in consumer behaviors. Holbrook argued that happy and experiential consumption known as fantasies, feelings, and fun extended broad experience, entertainment, exhibitionism, and recognition of "four Es" [3].

2.2 Experiential Marketing

The most efficient marketing campaigns make an immediate impact and hold attention of potential customers despite their normal short attention span. The long lasting connections built by experiential marketing increase loyalty between the consumers and the products, especially when consumers are allowed to try, compare, and experience the product or service by themselves. This experience makes customers feel comfortable by appealing to their emotions, sense and logic in a way that is more palatable than that of simply using traditional marketing to persuade consumers to buy a product designed for industrial. Experiential marketing is not just a sales trick, but it is a user experience. For careful consumers who dislike being "hustled" by traditional advertising and marketing strategies, it's a refreshing change of pace. Bernd Schmitt, explaining experiential marketing theory, said "Customers want to be entertained, stimulated, emotionally affected and innovative challenged". Experiential marketing is selling an experience that joint together your customer's hearts thereby purchase your products. Experience is not often a product of one's own initiative but is more often induced [5]. Experiential marketing appeals to a person's inner emotional psyche and life style to sell an experience which connects that person to a particular product. Schmitt [5] proposed the following experiential modules:

1. Sense marketing, which appeals to vision, hearing, smelling, taste, and touch by creating exceptional sensory experiences which provide enjoyment, agitation, and esthetics. For example, food sampling and taste testing of different flavors of salad dressing, cooking seasoning, coolies and the like at supermarkets are

examples of sensory experiential marketing, helping the customer to choose whether to buy them. Starbucks creates a similar experiential appeal with its high-quality coffee, graceful adornment, esthetic design, barista expertise and apron-style, jazz music chosen for its artistry and appeal.

2. Feel marketing employs an interactive and novel atmosphere to associate feeling of happiness, pride, and excitement to products. For example, slogans employed in military recruitment commercials appeal to a person's "pride in serving our country". Starbucks makes a third extraordinary place, to inspire, nurture, and clean your mind, between home and work for conversation- a place for passionate service, and a sense of community.
3. Think marketing stimulates intelligence, cognitive or systemic thinking, and problem solving in its creative approach. It spurs consumers to think innovatively and to evaluate companies and products by asking them in the words of Microsoft- "Where do you want to go next?" is followed by a connection between various office productivity concepts and the company's solutions. Starbucks places store by conducting its business responsibly and earning the trust and respect of its customers, employees, and neighbors, through initiatives such as ethical sourcing, environmental stewardship, community involvement, and shared planet issues.
4. Act marketing attempts to change consumer behavior or lifestyles by motivating them to a certain action. Schmitt suggests that consumers need extra motivation and stimulation, such as Nike and Adidas ads, which depended upon sports role models, LeBron James, Lionel Messi, and Cristiano Ronaldo, to show their commercial products. Starbucks is portrayed as a better place than one's home or office.
5. Relationship marketing appeals to an individual's need to interact and belong to others, a community or subculture which is often tied to symbolism attached to clothing, music and other visible affectations by members. For example, Atlanta Braves baseball team fans can shop for clothing with the Braves logo on it.

2.3 Decision Making Trial and Evaluation Laboratory Mathematical Model

The Decision Making Trial and Evaluation Laboratory (DEMATEL) method is made by the Battelle Memorial Institute of Geneva. DEMATEL is a multiple criteria decision making method that discusses the cause and effect relations among factors. It is an appropriate method which classifies factors of the problem into cause group (factors that have impact effect on others) and effect group (factors that receive impact influence from others) for analyzing and studying complicated problems such as race, famine, environment pollution, and energy issues [8–16]. DEMATEL are used to compute the effects between criteria. The model can propose the criterion which is the most important or affects other criteria the most, so Starbucks will understand which criterion can improve the service quality the most and can modify it.

3 Methodology

There are five constructs and 17 questions in the questionnaire. The opinions of ten experts who are managers in the coffee shops are collected by means of a matrix with questionnaire responses in this study. In according to two groups of factors, DEMATEL identifies the interdependence among factors. It converts the relationship between causes and effects of factors into a reasonable cause-effect model of structural system that have been applied to various scenarios and problems [9]. The scores by each expert will give a $n \times n$ non-negative answer matrix $\boldsymbol{X}^k = [x_{ij}^k]$, with $1 \leq k \leq H$. Thus, $X^1, X^2, \ldots, X^H$ are the answer matrices for each of the H experts, and each element of X^k is an integer denoted by x_{ij}^k. The diagonal elements of each answer matrix X^k are all set to zero. It can compute the $n \times n$ average matrix $\boldsymbol{A}$ for all expert opinions averaging the H experts' scores as following:

$$a_{ij} = \frac{1}{H}\sum_{k=1}^{H} x_{ij}^k$$

The average matrix $\boldsymbol{A} = [a_{ij}]$ is the initial direct relation matrix. $\boldsymbol{A}$ matrix presents the initial direct effects that a factor exerts on and receives from other factors. Then, the matrix D is obtained by normalized initial direct-relation matrix D where:

$$S = max\left[\max_{1 \leq i \leq n}\sum_{j=1}^{n} a_{ij}, \max_{1 \leq j \leq n}\sum_{j=1}^{n} a_{ij}\right]$$

$$\mathrm{D} = A/\mathrm{s}$$

$\boldsymbol{D}^2, \boldsymbol{D}^3, \ldots, \boldsymbol{D}^\infty$, guarantees convergent solutions to the matrix inversion similar to an absorbing Markov chain matrix. Note that $\lim_{m\to\infty} \boldsymbol{D}^m = [0]_{n\times n}$ and $\lim_{m\to\infty}\left(\boldsymbol{I} + \boldsymbol{D} + \boldsymbol{D}^2 + \boldsymbol{D}^3 + \cdots + \boldsymbol{D}^m\right) = (\boldsymbol{I} - \boldsymbol{D})^{-1}$, where *0* is the $n \times n$ null matrix and I is the $n \times n$ identity matrix. The total relation matrix $\boldsymbol{T}$ is an $n \times n$ matrix and is defined where:

$$\boldsymbol{T} = \left[t_{ij}\right] \cdots i, j = 1, 2, \ldots, n$$

$$\begin{aligned}
\boldsymbol{T} &= \boldsymbol{D} + \boldsymbol{D}^2 + \cdots + \boldsymbol{D}^m = \boldsymbol{D} + \boldsymbol{D}^2 + \cdots + \boldsymbol{D}^m \\
&= \boldsymbol{D}\left(I + \boldsymbol{D} + \boldsymbol{D}^2 + \cdots + \boldsymbol{D}^{m-1}\right) \\
&= \boldsymbol{D}\left[\left(I + \boldsymbol{D} + \boldsymbol{D}^2 + \cdots + \boldsymbol{D}^{m-1}\right)(1 - \boldsymbol{D})\right](1 - \boldsymbol{D})^{-1} \\
&= \boldsymbol{D}(\boldsymbol{I} - \boldsymbol{D})^{-1}, \text{ as } m \to \infty
\end{aligned}$$

It also defines ***D*** and ***R*** as *n * 1* vectors representing the sum of rows and sum of columns of the total relation matrix ***T*** as follows:

$$D = [r_{\mathrm{i}}]\, n^{*}1 = \left[\sum_{\mathrm{j}=1}^{\mathrm{n}} t_{\mathrm{ij}}\right] n^{*}1$$

$$R = \left[c_{\mathrm{j}}\right] 1^{*}n = \left[\sum_{\mathrm{i}=1}^{\mathrm{n}} t_{\mathrm{ij}}\right] \mathrm{n}^{*}1$$

The sum $(D_i + R_i)$ (Prominence) gives us an index representing the total effects both given and received by factor *i*. In other words, $(D_i + R_i)$ shows the degree of importance (total sum of effects given and received) that factor *i* plays in the system. In addition, the difference $(D_i - R_i)$ (Relation) shows the net effect that factor *i* contributes to the system. When $(D_i - R_i)$ is positive, factor *i* is a net causer, and when $(D_i - R_i)$ is negative, factor *i* is a net receiver [8].

4 Analysis

4.1 Questionnaire

This research questionnaire was established by Schmitt's experiential marketing model framework and method to analyze questions. (1) Sense Experiential Marketing: question 1, 2, 3, 4; (2) Feel Experiential Marketing: question 5, 6, 7, 8; (3) Think Experiential Marketing: question 9, 10, 11, 12; (4) Act Experiential Marketing: question 13, 14, 15. (5) Relationship Experiential Marketing: question 16, 17 depicted in Table 1 [17].

Customers' evaluation of service quality provided is a MCDM problem. They mentally group service quality provided and evaluation them by decision making process. Total relation matrix T was shown as Table 2 and sum $(D_i + R_i)$, difference $(D_i - R_i)$ in Table 3 but question 3, 11, 15, and 17 , with the least $D_i + R_i$ value "Business hours", "Payment rapid", "Promotion often", "Fashionable merchandised offering often", and do not reach interquartile range (IQR) to be deleted. The five service quality provided need with the highest $D_i + R_i$ value are "Public image", "Full of humanity service provide", "Shared Values Blog", "Humanistic space", and "Connected smile to customers". The five service quality need with the least $D_i + R_i$ value are "Business hours", "Payment rapid", "Promotion often", "Fashionable merchandised offering often", and "High quality coffee". The top three net causer service quality (factors) $(D_i - R_i > 0)$ are "Graceful adornment with artistry", "Humanistic space" and "Jazz music play". The top 3 net receiver service quality (factors) $(D_i - R_i < 0)$ are "Public image", "Customers interactions", and "Clean

Table 1 Schmitt's experiential marketing model for Starbucks [17]

Marketing strategy	Questions
Sense experiential	1. High quality coffee
	2. Clean and comfortable environment
	3. Payment rapid
	4. Customized coffee
Feel experiential	5. Jazz music play
	6. Graceful adornment with artistry
	7. Humanistic space
	8. Barista expert attitude
Think experiential	9. Reasonable prices
	10. Public image
	11. Business hours
	12. Customers interactions
Act experiential	13. Full of humanity service provide
	14. Connected smile to customers
	15. Promotion often
Related experiential	16. Shared values blog
	17. Fashionable merchandised offering

Table 2 Total relation matrix *T*

T	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0.02	0.03	0.00	0.10	0.01	0.02	0.02	0.09	0.10	0.11	0.00	0.03	0.03	0.03	0.00	0.03	0.00
2	0.02	0.05	0.01	0.03	0.05	0.11	0.12	0.03	0.03	0.13	0.01	0.09	0.11	0.07	0.00	0.05	0.00
3	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.00	0.03	0.05	0.03	0.00	0.02	0.00
4	0.08	0.04	0.01	0.04	0.02	0.03	0.04	0.07	0.11	0.14	0.01	0.10	0.09	0.08	0.01	0.12	0.01
5	0.02	0.12	0.01	0.04	0.02	0.04	0.05	0.05	0.04	0.14	0.01	0.11	0.13	0.10	0.01	0.11	0.00
6	0.04	0.15	0.01	0.06	0.11	0.06	0.15	0.09	0.10	0.18	0.01	0.16	0.16	0.15	0.01	0.16	0.01
7	0.08	0.15	0.07	0.12	0.11	0.11	0.08	0.09	0.13	0.19	0.05	0.17	0.17	0.15	0.01	0.17	0.01
8	0.11	0.10	0.01	0.12	0.04	0.06	0.07	0.04	0.12	0.16	0.03	0.10	0.10	0.09	0.01	0.12	0.00
9	0.10	0.07	0.01	0.11	0.02	0.05	0.05	0.07	0.04	0.14	0.01	0.07	0.07	0.06	0.02	0.08	0.00
10	0.03	0.12	0.01	0.06	0.03	0.08	0.10	0.06	0.05	0.08	0.03	0.14	0.14	0.13	0.01	0.12	0.00
11	0.01	0.01	0.00	0.01	0.00	0.01	0.03	0.01	0.02	0.01	0.00	0.05	0.01	0.01	0.00	0.03	0.00
12	0.03	0.05	0.01	0.04	0.03	0.04	0.12	0.07	0.03	0.14	0.01	0.06	0.13	0.09	0.01	0.13	0.01
13	0.08	0.14	0.01	0.11	0.09	0.13	0.15	0.09	0.06	0.18	0.01	0.16	0.09	0.15	0.01	0.16	0.01
14	0.11	0.14	0.05	0.13	0.04	0.11	0.13	0.09	0.09	0.18	0.01	0.16	0.16	0.07	0.01	0.15	0.01
15	0.06	0.02	0.06	0.07	0.01	0.02	0.03	0.03	0.10	0.05	0.06	0.07	0.04	0.03	0.01	0.11	0.08
16	0.04	0.07	0.01	0.11	0.07	0.08	0.13	0.10	0.09	0.17	0.01	0.16	0.15	0.12	0.05	0.09	0.04
17	0.04	0.05	0.01	0.06	0.02	0.03	0.04	0.03	0.09	0.11	0.01	0.11	0.08	0.08	0.08	0.12	0.01

and comfortable environment". The X-axis is D + R (Prominence) and Y-axis is D – R (Relation); the center of prominence and relation matrix grid is average D + R and D – R (2.16, 0). As shown in Fig. 1, Quadrant I has graceful adornment and connected smile to customers; quadrant II has jazz music play, humanistic space, and Barista expert attitude; quadrant III has high quality coffee, reasonable prices,

Table 3 D + R and D − R

D		R		D + R		D − R	
Ranking	Value	Ranking	Value	Ranking	Value	Ranking	Value
7	1.86	10	2.17	10	3.35	17	0.78
14	1.63	12	1.77	13	3.34	6	0.65
13	1.63	16	1.76	16	3.27	15	0.60
6	1.60	13	1.71	7	3.17	7	0.56
16	1.51	14	1.43	14	3.07	5	0.33
8	1.27	7	1.30	12	2.72	8	0.25
10	1.17	2	1.29	6	2.55	14	0.20
4	0.99	9	1.22	8	2.29	3	−0.02
5	0.99	4	1.22	4	2.20	11	−0.04
17	0.97	8	1.02	9	2.18	13	−0.09
9	0.96	6	0.95	2	2.18	4	−0.23
12	0.95	1	0.89	5	1.65	1	−0.25
2	0.89	5	0.66	1	1.52	9	−0.26
15	0.84	3	0.29	17	1.17	16	−0.26
1	0.63	11	0.25	15	1.07	2	−0.41
3	0.27	15	0.24	3	0.56	12	−0.81
11	0.21	17	0.20	11	0.47	10	−1.00
				Mean	2.16	Mean	0.00

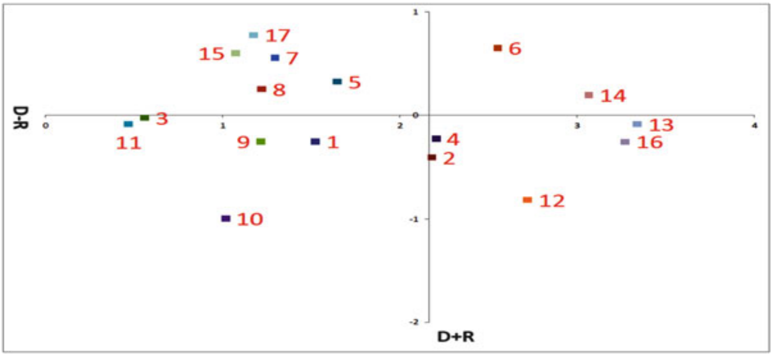

Fig. 1 Prominence and relation matrix grid

and public image; quadrant IV has clean and comfortable environment, customized coffee, customers interactions, full of humanity service provided, and Share Value Blog. “Graceful adornment with artistry” and “Connected smile to customers” are the most crucial influence factors to others. “Customers interactions” and “Share Values Blog” are the most to be influenced factors to others.

5 Conclusions

This study applied Schmitt's experiential marketing framework to investigate service quality provided of Starbucks by DEMATEL method. It found that the major service quality provided evaluation criteria are public image (maintain a desirable image for high-profile organization), full of humanity service provided (tending and befriending virtue), Shared Value Blog (interaction people around the world), humanistic space (value and ethic of human being), connected smile to customers (have fun with friendly). Starbucks is successful to make a third extraordinary place to inspire, nurture, and clean customers' mind, beyond home and office- a third place for passionate with humanity service, and a smile as the cup is delivered across the counter to customers where jazz music and graceful adornment chosen for its artistry; it places great store by conducting its business responsibly and the trust of its customers, comfortable esthetic and humanistic environment, and human interactions within Marcel Proust style, but they should be not happy if it does not provide completely. Meanwhile, in the technology age also has transformed communication from a merely functional exercise to entertainment, its app appeals to the iPhone crowd or Shared Values Blog to share or communicate their happy experience or ideas and see what other people suggests at "My Starbucks idea", Facebook, YouTube, Twitter, Pinterest, or Google, as helping Sumatran farmers respond to climate change issue. Although it is not a modern phenomenon, does make Starbucks' service quality provided seem like an stimulated, smart, and cutting-edge method that may make Starbucks' brand more vital to customers who might become saturated with emotional appeals.

Starbucks emotional appeals or touchy-feely targets at those who want to be fantasy, feeling, fun, happy, entertainment, stimulated, creative challenge, interaction and artistry, thus nothing concerns about prices, promotion, payment rapid, and those practical things within a sensory third place only to enjoy themselves heartily, terms of Starbucks people. In fact, it has done completely its mission statement "Our mission: to inspire and nurture the human spirit – one person, one cup and one neighborhood at a time"; "Always full of humanity". This practical study provides valuable and favorable impressive information to Starbucks or retail outlets' managers.

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Music Platform Competition and Advertising Strategy in the Duopoly Music Industry

Yi-Shin Lin and Yu-Shing Chang

Abstract Information technologies "weed out" the old and bring forth new industries, such as the Otaku Economy Markets and Knowledge Sharing Platforms, and influence traditional industries, especially digitization products. Digital industries also encounter several challenges (e.g., piracy and virtual channels) because of the popularization of the Internet. Hence, we used a game theory approach to compare two competing music platforms with and without paid services. We show that the paid music platform does not earn excess profits, and the relationship between socially optimal advertising and basic utility of virtual digital products are parabolically related.

Keywords Advertising strategy • On-line music • Social welfare • Two stage game approach

1 Introduction

Information technologies "weed out" the old and bring forth new industries, such as Otaku Economy Markets (e.g., Facebook, Plurk, YouTube, online games, online movies, and online music) and Knowledge- Sharing Platforms (e.g., Yahoo Knowledge^{+}, UrCosme, and Fashion Guide). These industries also influence traditional industries, especially digitization products.

Therefore, Taiwan's government authority and software firms repeatedly advise consumers to avoid pirated software, to establish the concepts of intelligence property right and copyright. In the last decade, to reduce widespread software piracy in the domestic market and protect software firms, the government has

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legislated laws such as the copyright law, the intelligence property right law, and the optical media law. Because software piracy is costless and pirated software is identical to the original, software has a relatively higher possibility of piracy than other products, such as journals, books, and cassettes [1]. This substantially lowers the profits of software firms and deteriorates social welfare.

Zentner [2] used phonebook records for the years 1998 and 2002 to analyze the manner in which online sales of records and music downloads affected the creation and destruction of brick and mortar music specialty record stores. His results suggested that file sharing may have increased the decline of brick and mortar music stores and reduced their numbers, and the reduction in the number of stores near universities was explained by a lower creation of music stores in these locations. Simultaneously, changes in politics, science, technology, markets, economy, and habits caused a virtual space community in the music industry [3]. Furthermore, Cunningham et al. [4] presented a model in which users chose their level of sharing, downloading, and listening in the presence of sharing costs and endogenous downloading costs. Their model predicts that free-riding must preclude the success of the community. However, a great number of scholars lacked for advertising effect of their research, so our considered it on our model.

We developed a model for two digital platforms in the market, for which revenues are obtained in differing manners, such as membership fees or advertisement. We analyzed the effects of revenue on the digital platform, consumer surplus, social welfare, and equilibrium advertising level. We used the model of spatial competition for the inside location game [5] and solved the equilibrium by sub-game perfect equilibrium and backward induction.

The remainder of this paper is organized as follows: Sect. 2 presents a brief review of the relevant literature of piracy, advertisement, and moral judgment; Sect. 3 introduces a model with three types of agents (members, digital platforms, and advertisers); Sect. 4 provides a solution for the equilibrium number of digital platforms that advertise; Sect. 5 provides a comparison of the equilibrium of advertisement expense and membership fee; and finally, Sect. 6 presents our findings and managerial implications of the results.

2 Related Research

Competition among products is intense, and several companies advertise new products in various manners to attract the attention of consumers. However, advertisements use several approaches, as follows: (a) advertising media, such as traditional media and Web media; and (b) advertisement formats, such as traditional formats and Web site formats. Hence, it is crucial to determine the manner in which to attract the attention of consumers using advertisements. Our paper is related to the literature on Web advertisements in digital product markets, the recent literature on two-sided markets and the recent literature on Moral Judgment.

2.1 Advertisements

We contribute to the literature on Web advertisements of online digital products by introducing the option to set advertisements. Previous analyses in the digital market literature focused on the behavior of consumers or firms. Advertisements are crucial in these cases because record companies enter virtual channels to sell their music. Anderson and Coate [6] found that lower advertising levels and more programming are not necessarily socially desirable. Gabszewicz et al. [7] verified that the program mixes of the channels do not converge when ad interruptions are costly for viewers, and that the niche strategies are less effective and the channel profiles are closer as advertising aversion becomes stronger. Zhou [8] found that commercial breaks become more frequent toward the end of the program or the television program becomes more popular. Hence, Gantman and Shy [9] compared the equilibrium levels of advertising to the socially optimal levels in the broadcasting industry and demonstrated that quality improvement is profitable for the advertising firms, but not for the broadcasters. A recent addition to the literature is the work by Peitz and Valletti [10], who compared the advertising intensity and content of programming in the competing media platforms and found that viewers strongly dislike advertising. Fan et al. [11] found that, as the advertisement revenue rate increases, the advertising level must remain low, and as digital video recorder technologies provide more convenience to consumers, media companies must increase, rather than decrease, revenues from advertising. Therefore, Lin and Li [12] found that the duopolistic market professional ability of channel firms is beneficial to contextual advertising, and acquisition becomes a prime strategy to reveal the value of contextual advertising.

2.2 Moral Judgment

In the literature on moral judgment and two-sided markets, Huang [13] presents a conceptual model of sharing through a set of hypotheses, and investigated music file-sharing behavior from the perspectives of moral judgment, expertise, and social networking. The same model was used by Chen et al. [14]. They analyzed 834 samples of P2P users in Taiwan and found that moral reasoning moderated the relationships among fashion involvement, consumption value, and behavioral intention to download music. Chou [15] considered two sided markets in which a number of broadcast stations are financed through subscription and advertising revenues, whereas other broadcast stations are financed only through advertising revenues.

Most of this research has focused on pricing policies, protection against piracy, and governmental policies in the music industry. However, the literature does not analyze the effects of hybrid channels (entry channels and virtual channels) on the profits of the digital product companies by the industry economics or e-economics. We developed a model in which a digital product company operates two channels on digital products to control the market share and profit margin.

3 A Model of Members, Digital Platforms, and Advertisers

Consider an economy with two digital platforms (A and B) competing simultaneously in the digital products market. The only source of revenue of Digital Platform B is from advertisers who pay f_B for placing advertisements, and the source of revenue of Digital Platform A is from members who pay p_A for downloading music.

3.1 Members

Music user types are uniformly distributed on the interval [0, 1] [16]. The location index number t is the widely used differentiation characteristic parameter of a music user. Thus, users indexed by t toward 1 are interpreted as those who gain the most benefit from buying music from Digital Platform A, whereas users indexed by t toward 0 are interpreted as those who gain little from using music from Digital Platform B. Each user uses a maximum of one unit of music to download the music of A for price p_A, or download the music of B for free. Hence, consumers have two choices: (a) consumers join Digital Platform A; or (b) consumers join Digital Platform B.

The utility of each user indexed by t ($0 \leq t \leq 1$) can be specified as

$$U_t \stackrel{def}{\equiv} \begin{cases} \beta + \gamma n_A - p_A & \textit{Platform} \quad A \\ \beta\,(1 - \lambda_{\mathrm{B}}) + \gamma n_{\mathrm{B}} & \textit{Platform} \quad B \end{cases}. \tag{1}$$

Let the parameters $\beta > 0$ be a user's basic valuation for the music provided by the digital platform. A higher value of β is indicative of more valuable platform service provided. The parameters $\gamma \geq 0$ and $n \geq 0$ represent the intensity of the network size effect (γ) from the number of users (n). Specifically, $\gamma > 0$ indicates that higher platform use signifies higher utility of the user. $n_A > 0$ and $n_B > 0$ represent the number of Platform A and Platform B. Platform A charges p_A from the users, whereas Platform B charges from the advertisers. Let λ_B denote the number of advertisements by Platform B and measure the fraction of a music platform allocated to advertisement. We assume λ_B to satisfy $0 < \lambda_B < 1$, where the advertisement becomes more frequent, and the basic valuation of members decrease to lower the number of members of the platform. Finally, with no loss of generality, we simplified the model by setting the marginal cost of the digital platform to zero.

All users indexed on $[0, \hat{t}]$ join Digital Platform A, whereas all users indexed on $[\hat{t}, 1]$ join Digital Platform B. Similarly, let $\hat{t}$ denote the type of a marginal user who is indifferent to joining Digital Platforms A and B. Hence, $\beta + \gamma n_A - p_A = \gamma n_B + \beta(1 - \lambda_B)$ for a consumer $\hat{t}$, where n_{A} $(n_A = \hat{t})$ denotes the number of members of Platform A, and n_{B} $(n_B = 1 - \hat{t})$ denotes the number of members of Platform B. By substituting n_{A} and n_{B}, we yield the equilibrium numbers

$$\hat{t} = \frac{a+b}{2} + \frac{p_A - \beta\lambda_B}{2\gamma}, \tag{2}$$

i.e.,

$$n_A = \frac{1}{2} + \frac{p_A - \beta\lambda_B}{2\gamma} \tag{3}$$

and

$$n_B = \frac{1}{2} - \frac{p_A - \beta\lambda_B}{2\gamma}. \tag{4}$$

3.2 Advertiser

Similarly, advertisement user types are uniformly distributed on the interval [0, 1], and each advertiser uses a maximum of one unit of advertisement in Digital Platform B. The location index number x is the widely used differentiation characteristic parameter of an advertiser. Thus, advertisers indexed by x toward 1 are interpreted as those who like to advertise on Digital Platform B, whereas advertisers indexed by x toward 0 are interpreted as those who dislike advertising on Digital Platform B. Each advertiser uses a maximum of one unit of advertisement to display the advertisement of Platform B for advertising expenditure f_B. Hence, advertisers have two choices: (a) advertise on Digital Platform B; or (b) do not advertise.

The profit functions of advertisers is defined by

$$\pi_x \equiv \begin{cases} n_B\varphi - \delta(1-x) - f_B & \textit{advertises in platform B} \\ 0 & \textit{does't advertise} \end{cases}. \tag{5}$$

Let f_B denote advertisement expense; higher advertising expenses result in lower profit. In addition, advertisers prefer to publish the advertisement decided by the membership of this digital platform, and a higher membership of the digital platform indicates a higher advertising effect, φ, which increases the revenue. Moreover, the amount of advertising and the number of commercial breaks occasionally cause a negative advertising effect, δ.

Let $\widehat{x}$ denote the type of a marginal advertiser who is indifferent to advertising on Digital Platform B and non-advertisement. All advertisers indexed on $[\widehat{x},1]$ advertise on Digital Platform B, and all advertisers indexed on $[0, \widehat{x}]$ do not advertise. Hence, $n_B\varphi - \delta(1 - x) - f_B = 0$ for an advertiser, $\widehat{x}$, where n_{B} ($n_B = 1 - \widehat{x}$) denotes the number of advertisements of Platform B. Substituting n_{B} yields

$$\widehat{x} = 1 - \frac{n_B\varphi - f_B}{\delta}. \tag{6}$$

3.3 Digital Platform

The profit of Digital Platform A comes from membership fees, and the profit of Digital Platform B comes from advertising expenditure. Finally, with no loss of generality, we simplified the model by setting the marginal cost of digital products to zero. Hence, the profit function of Digital Platforms A and B are defined by

$$\pi_A = p_A n_A, \tag{7}$$

and

$$\pi_B = f_B\,(1 - \widehat{x})\,. \tag{8}$$

4 Equilibrium Analysis

We assume that memberships, advertisers, and digital platforms interact according to the following three stages. Stage one, the revenue of Digital Platform B comes from advertisers who pay f_B, and the revenue of Digital Platform A comes from members who pay p_A to maximize profit. Stage two, each advertiser determines whether to advertise in n_B to maximize profit. Stage three, each consumer considers the advertising levels and membership fee of digital platforms and subsequently determines the platform to join to maximize utility.

4.1 Membership Fee and Advertisement Expense

Substituting (3) into (7) yields

$$\max_{p_A} \pi_A = p_A\left(\frac{1}{2} + \frac{p_A - \beta\lambda_B}{2\gamma}\right). \tag{9}$$

Thus, by maximizing (9), the profit-maximizing membership fee p_A of Platform A is derived by

$$p_A = \frac{\beta\lambda_B - \gamma}{2}. \tag{10}$$

Similarly, substituting (6) into (8) yields

$$\max_{f_B} \pi_B = f_B \frac{\varphi\, n_B - f_B}{\delta}. \tag{11}$$

By maximizing (10), the profit-maximizing advertising expense f_B of Platform B is derived by

$$f_B = \frac{n_B\varphi}{2} \tag{12}$$

4.2 Membership

Substituting the equilibrium membership fee (10) into (2) to (4) yields the number of consumers downloading music at Digital Platforms A and B as

$$\hat{t} = \frac{3a+b}{4} - \frac{\beta\lambda_B}{4\gamma}, \tag{13}$$

$$n_A = \frac{1}{4} - \frac{\beta\lambda_B}{4\gamma}, \tag{14}$$

and

$$n_B = \frac{3}{4} + \frac{\beta\lambda_B}{4\gamma}. \tag{15}$$

4.3 Advertisers

According to the equilibrium advertising expense (12) and the equilibrium membership fee (14) placed into (6), we can obtain

$$\hat{x} = 1 - \frac{\varphi\,(3\gamma + \beta\lambda_B)}{8\delta\gamma}. \tag{16}$$

λ_B equals the number of advertisers in $[\widehat{x}, 1]$,

$$\lambda_B = 1 - \widehat{x} = \frac{3\gamma\varphi}{4\,(2\delta\gamma - \beta)}. \tag{17}$$

By substituting (15) and (17) into (12), we can obtain the advertising expense.

$$f_B = \frac{\varphi}{8}\left(3 + \frac{\beta\lambda_B}{\gamma}\right). \tag{18}$$

The following result was obtained from (17).

Result 1 (1) If the parameter β is smaller than $2\gamma(0.5\delta - 3\varphi)$ and λ_B is smaller than one, Digital Platform B has advertisements. (2) The higher basic utility of Product V in Digital Platform B is the higher memberships, and the higher memberships result in higher advertising benefit.

By substituting (17) into (10), (18), (14), and (15), we can obtain these equilibriums as follows:

$$p_A = \frac{\gamma}{2}\left(\frac{3\beta\varphi}{4\,(2\delta\gamma - \beta)} - 1\right), \tag{19}$$

$$f_B = \frac{3\varphi}{8}\left(1 + \frac{\beta\varphi}{4\,(2\delta\gamma - \beta)}\right), \tag{20}$$

$$n_A = \frac{1}{4}\left(1 - \frac{3\beta\varphi}{4\,(2\delta\gamma - \beta)}\right), \tag{21}$$

$$n_B = \frac{3}{4}\left(1 + \frac{\beta\varphi}{4\,(2\delta\gamma - \beta)}\right). \tag{22}$$

Profit-maximizing of Platforms A and B obtained the following results.

Result 2 The price of Platform A (p_A) and advertising expenditure of Platform B (f_B) may be positive under the premise that $2\delta\gamma > \beta > \tilde{\beta}$ is known, where $\tilde{\beta} = \frac{8\delta\gamma}{3\varphi+4}$.

Result 3 The membership of Platforms A (n_A) and B (n_B) may be positive under the premise that $\beta < \widehat{\beta}$ and $\beta < 2\delta\gamma$ are known, where $\widehat{\beta} = \frac{8\delta\gamma}{3\varphi+4}$.

5 Discussion and Analysis

We determined the welfare implications of introducing the option of asking for a membership fee or publishing advertisements. Suppose that we define social welfare as $SW = CS + PS$, where CS is the consumer surplus for consumers using online music, and PS is the product surplus for digital platforms and advertisers.

We substituted (10), (3), and (14) into (1) and yielded the consumer's surplus (CS).

$$CS = \frac{(\gamma - \beta\lambda_B)(\beta(8 - 5\lambda_B) + 5\gamma)}{32\gamma} + \frac{(3\gamma + \beta\lambda_B)(\beta(8 - 7\lambda_B) + 3\gamma)}{32\gamma}. \quad (23)$$

Subsequently, by substituting (19) and (21) into (7), we can yield the profit of Digital Platform A.

$$\pi_A = -\frac{(\gamma - \beta\lambda_B)^2}{8\gamma}. \quad (24)$$

Finally, by substituting (17) and (20) into (8), we can yield the profit of Digital Platform B

$$\pi_B = \frac{3\varphi^2(3\gamma + \beta\lambda_B)}{32(2\delta\gamma - \beta)}, \quad (25)$$

and the profit of the advertiser

$$\pi_x = \int_x^1 (\varphi n_B - \delta + \delta x - f_B)\, dx = \frac{\varphi}{8}\left(3 + \frac{\beta\lambda_B}{\gamma}\right). \quad (26)$$

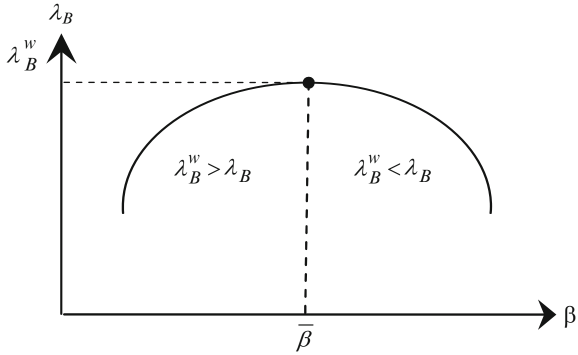
Platform A, Platform B, and the advertisers are producers; therefore, PS includes platforms and advertisers ($PS = \pi_A + \pi_B + \pi_x$). We can yield

$$PS = \frac{\varphi(3\gamma + \beta\lambda_B)}{8}\left(\frac{1}{\gamma} + \frac{3\varphi}{4(2\delta\gamma - \beta)}\right) - \frac{(\gamma - \beta\lambda_B)^2}{8\gamma}. \quad (27)$$

and $SW = CS + PS$; subsequently,

$$SW = \frac{(\gamma - \beta\lambda_B)}{32\gamma}(8\beta - \beta\lambda_B + \gamma) + \frac{(3\gamma + \beta\lambda_B)}{32\gamma}\left(\beta(8 - 7\lambda_B) + 3\gamma + 4\varphi + \frac{3\gamma\varphi^2}{(2\delta\gamma - \beta)}\right). \quad (28)$$

Fig. 1 Equilibrium advertising level and optimal advertising level



By maximizing (28), the optimal advertising level λ_B^w is derived by

$$\lambda_B^w = \frac{(2\varphi - 9\gamma)}{7\beta} + \frac{3\gamma\varphi^2}{14\beta\,(2\delta\gamma - \beta)}. \tag{29}$$

By comparing the result between (17) and (29). Then, by maximizing social welfare, if the basic utility is lower than $\overline{\beta}$, the market may increase advertising. In other words, Platform B can accept more advertising, and vice versa (see Fig. 1).

6 Conclusion

Information technologies "weed out" the old and bring forth new industries, such as the Otaku Economy Markets and Knowledge – Sharing Platforms. This simultaneously influences numerous traditional industries, especially digitization products, and digital industries encounter several challenges (e.g., piracy and virtual channels) because of the popularization of the Internet. Hence, some music companies join the market of virtual channels to increase the channel competence and some only sell virtual digital products to stop piracy.

If two platforms are used to manage the same digital products, one platform earns profit from membership fees and the other earns profit from advertisement expenses. Under this situation, we find the optimal advertising level and the basic utility present a parabola relationship.

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A Study of Efficiency Valuation in Bank Industry – Evidence from Taiwan

Iuan-yuan Liu, Wen-hua Shen, and Wei-wen Hsiao

Abstract This study adopt fixed assets, SG&A (selling, general and administrative expenses) and interest expenses as input factors, use the amounts of loans and revenues as output factors, and employ Data Envelopment Analysis (DEA) to evaluate the efficiency performance and relative efficiency of commercial banks according to Farrell's efficiency evaluation theory. We group all sample commercial banks into three categories, namely "Old Commercial Banks", "New Commercial Banks" and "Commercial Banks Upgraded from Credit Cooperatives" and evaluate the efficiency of commercial banks, including overall efficiency, overall technical efficiency, pure technical efficiency, scale efficiency, and allocation efficiency. The empirical results find that the "Old Commercial Banks" possess highest efficiency value than the other two groups. Besides, the "Old Commercial Banks" also have the highest overall technical efficiency, pure technical efficiency and allocative efficiency. It implies that the "Old Commercial Banks" is doing well in competing with the new entrants, which makes them keep better efficiency than both the "New Commercial Banks" and the "Commercial Banks Upgraded from Credit Cooperatives".

Keywords Allocation efficiency • Overall efficiency • Overall technical efficiency • Pure technical efficiency • Scale efficiency

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1 Introduction

The economic environment is not that benefit to banks like past decades and the competition in banks industry becomes fiercer than before. From the point view of utilization of resources, a commercial bank must endeavor to maximize the utilization of resources owned to create advantages and margins in order to survive in poor economic conditions and high competitive environment. Thus, we employ Data Envelopment Analysis (hereafter DEA) to measure the efficiency of commercial banks, attempt to delineate a picture of efficiency assessment of commercial banks in Taiwan and try to capture the reason of assets utilization inefficiency in some commercial banks.

To assess the efficiency of commercial banks in Taiwan, we employ following steps to implement DEA process. First, we consider banks industry environment, and discuss with some senior bankers to find out important input variables and output variables of commercial banks, which will be used as main variables to assess efficiency value in our study. Second, we use Charnes et al.'s model (hereafter CCR model) [1] to estimate "Overall Technical Efficiency (OTE)", "Scale Efficiency (SE)", and "Allocative Efficiency" for all individual commercial banks. These estimated values range between 0 and 1. The higher the value is, the more efficient the commercial bank is. We use these efficiency values to make comparison among commercial banks, which enable us to identify which is the most efficient commercial bank and which is the worst. Then, we can provide some suggestions regarding to resources inputs and allocation decisions to individual commercial bank according to efficiency evaluation results. Third, As the CCR model assume a constant return to scale when make efficiency evaluation, Banker et al. [2] develop another model as an adjustment of "constant return to scale" assumption and an alternative model of CCR model, which is called BCC model. We adopt BCC model to measure "Pure Technical Efficiency (TPE)" as well as "Scale Efficiency (SE)" and identify the causes of inefficiency of TPE and SE, which will be useful to provide advices to individual bank about whether to increase scale, maintain recent scale, or to down size scale. Fourth, we divide commercial banks into three groups, i.e., "New Commercial Banks", "Old Commercial Banks" and "Commercial Banks Upgraded from Credit Cooperatives" according to their ages, scales and characteristics, then compare the overall efficiency of these groups to investigate whether there are significant efficiency deviations among them. Besides, we employ "Slack Variables Analysis" to examine the reason of inefficiency in these commercial banks and give some improvement directions to those relatively inefficient commercial banks.

Our study contributes to extant literatures in two ways. First, we select input and output variables according to the suggestion of senior bankers which will make empirical results more precisely in gauging commercial bank's efficiency. Second, we find that the "Old Commercial Banks" have highest efficiency values in overall efficiency, overall technical efficiency, pure technical efficiency and allocative efficiency. That means that the new entrants like"New Commercial Banks" and

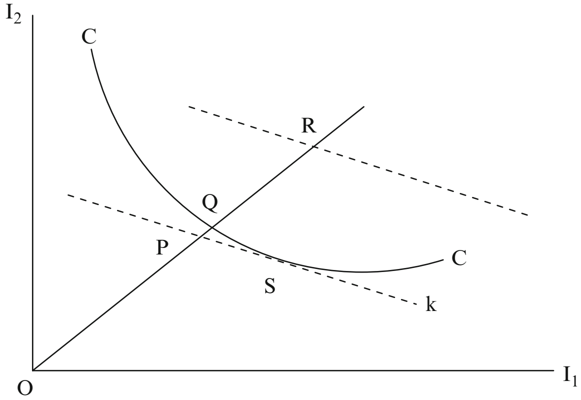

Fig. 1 Overall and allocative efficiency

"Commercial Banks Upgraded from Credit Cooperatives" may be given too much expectation on their performance just because they are new to the market. In contrast with the other two groups, the relatively high efficiency value of the "Old Commercial Banks" may imply that although the "Old Commercial Banks" confront with fiercer competition than before, they still keep a lot of advantages in the market, which will make them easier to compete with the new entrants having relatively less resources. Furthermore, as the competition in banks industry is getting fiercer than before, it may push the "Old Commercial Banks" to adjust their traditional mindset, move forward and refocus on what they live by. Thus, maybe more competition is the best way to push old financial institutions like the "Old Commercial Banks" to improve efficiency.

Plenty of prior studies use DEA model to evaluate the management efficiency of banks [3–8]. Efficiency usually represents the ratio of output over input, which mean using fewer amounts of input than needed as usual, but producing same amount of output as it used to be, or using same units of input as usual but generating more output than it used to be. High efficiency means high productivity and more cost savings. Robin [9] indicates efficiency as the relationship between input and output. Norman and Stoker [10] define efficiency as "the use made of resources in the attainment of outputs, in the context of environmental factors". The other definition provided by Cooper et al. [11] expressing efficiency as an extension statement of Pareto-Koopmans's definition, which refers "full efficiency is attained by any decision making units (hereafter DMU) if and only if none of its inputs or outputs can be improved without worsening some of its other inputs or outputs." They also defines relative efficiency as "if and only if the performances of other DMUs does not show that some of its inputs or outputs can be improved without worsening some of its other inputs or outputs". Farrell's argument [12] about efficiency is a fundamental cornerstone of the theory of efficiency measurement. He decomposed overall economic efficiency into components of technical efficiency and allocative efficiency, which is presented as Fig. 1.

In Fig. 1, the curve CC represents an "isoquant" outputs produced by two different amounts of inputs (I_1, I_2). This curve means the "efficiency frontier" of the "production possibility set", for which with an output on the isoquant, it is not possible to reduce the input of I_1(or I_2) without increasing the other input I_2(or I_1). The dashed line k represents isocost line (or budget line) for which (I_1, I_2) pairs on this lines yield the same total cost with unit costs of I_1 and I_2 separately. As the k intersects the production possibility set at S and represents the minimum cost needed to produce a specific output, thus point S is therefore said to be "allocatively" as well as "technically" efficient. Furthermore, the point P intersects the cost line k with the ray from O to R. Using a radial measure, the ratio of OP over OR is identified as "overall efficiency". The ratio of OQ over OR is deemed as a radial measure of "technical efficiency", which is similar to refer "the amount of waste that can be eliminated without worsening any input or output". Technical efficiency is further distinguished by Farrell from "allocative efficiency" and "scale efficiencies". In Fig. 1, the ratio of OP over OQ is called as a radial measure of "allocative efficiency" which is also referred to as "price efficiency" by Farrell [12]. Thus, the product of allocative efficiency and technical efficiency will exactly equal to overall efficiency in these radial measures. According to Farrell's decomposition of efficiency [12], the technical efficiency can be further divided into "pure technical efficiency" and "scale efficiency".

2 Methodology

Using commercial banks' data collected from Taiwan Economic Journal (TEJ) databank and official publications of Bank Associations, We adopt DEA models to measure the efficiency of a DMU relative to similar DMUs, which make it possible to estimate a 'best practice' frontier. The initial DEA model was built on the earlier work of Farrell [12], and originally provided by Charnes et al. [1].

Regarding to DEA procedure, Golany and Roll [13] suggest following three steps in implementing DEA process: (1) define and select decision making units (DMUs); (2) seek for appropriate input and output items or analysis; (3) apply DEA model to implement efficiency evaluation. Golany and Roll [13] also suggest that the number of DMUs should be at least two times of the total number of input and output items according to rule of thumb. We collect financial and fundamental data of 38 commercial banks (as decision making units in DEA measurement) in Taiwan during the period of 2001, which is about 10 year after the banks industry deregulation, and divide those commercial banks into three groups named as "Old Commercial Banks" and "New Commercial Banks" and "Commercial Banks Upgraded from Credit Cooperatives". The number of commercial banks in those three groups is 10, 16, and 12 respectively. Then, we define input and output variables of commercial banks in accordance with theother literatures and discussion with senior bankers. We use fixed assets, interest expenses and Selling, General and Administration Expenses (SG&A expenses) as main input variables, which represent long-term assets inputs, capital inputs, and manpower inputs respectively. Second, we use the total amount of loans and revenues as output variables which are generated by the inputs mentioned above. Finally, we implement DEA model to estimate the efficiency value of the sample banks.

3 Results

We implement CCR model to measure the "overall efficiency" of commercial banks in Taiwan using input and output data collected from TEJ. Table 1 presents the results of Slack Variable Analysis, which indicates that how many inputs should be saving and how many outputs need to be increased for individual commercial banks in order to enhance their efficiency. In average, the results shows that the commercial banks should save inputs of fixed assets by 27.66 % less than current investment amount, about 8.83 % saving in SG&A, and 4.62 % saving in interest expenses. On the other hand, they should increase the amount of loans by 2.37 % and augment revenues by 1.10 %.

Table 2 shows the overall efficiency, overall technical efficiency, pure technical efficiency, scale efficiency and allocative efficiency of commercial banks respectively. We show all the efficiency by groups and exhibit the average efficiency value on Table 3.

The results in Table 3 shows that the average of overall efficiency value of all commercial banks, "Old Commercial Banks", "New Commercial Banks", "Commercial Banks Upgraded from Credit Cooperatives" is 0.9259, 0.9743, 09419 and 0.9003 respectively, which indicates the "Old Commercial Banks" possess the higher overall efficiency than the other groups. And only the average efficiency value of "Old Commercial Banks" is above the overall average. Besides that, the "Old Commercial Banks" also have the highest overall technical efficiency, pure technical efficiency and allocative efficiency.

The results of Table 4 indicates that the mean overall efficiency, overall technical efficiency and scale efficiency of the "Old Commercial Banks" are all significantly larger than those of the "Commercial Banks Upgraded from Credit Cooperatives" at $\alpha = 0.1$ significance level. The mean pure technical efficiency of the "Old Commercial Banks" is significantly larger than that of the "New Commercial Banks" at $\alpha = 0.1$ significance level. Finally, the mean scale efficiency of the "New Commercial Banks" is significantly larger than that of the "Commercial Banks Upgraded from Credit Cooperatives" at $\alpha = 0.1$ significance level. As for the allocative efficiency, there is no significant difference among the three groups at $\alpha = 0.1$ significance level.

Table 1 Slack variable analysis of inputs and outputs

Code of bank	Inputs saving needed			Outputs improvement needed	
	Fixed assets	SG&A	Interest expenses	Loans	Revenues
A1	0	0	0	0	0
A2	0	0	0	0	0
A3	10,827	1,606	2,491	0	0
A4	0	0	0	0	0
A5	13,183	301	579	0	3,503
A6	5,385	864	1,653	84,981	0
A7	12,187	133	219	0	0
A8	3,013	129	137	0	0
A9	1,289	180	290	0	0
A10	2,287	213	466	0	0
B1	887	3,111	981	0	0
B2	327	586	971	0	328
B3	302	636	645	25,278	0
B4	0	0	0	0	0
B5	214	490	463	0	0
B6	0	0	0	0	0
B7	2,801	222	421	13,613	0
B8	2,004	37	64	0	0
B9	2,192	205	363	0	0
B10	2,028	703	1,359	0	798
B11	4,092	10,067	2,347	0	3,350
B12	0	0	0	0	0
B13	0	0	0	0	0
B14	1,699	260	467	0	0
B15	957	242	537	0	0
B16	340	623	972	0	360
C1	4,595	759	866	77,523	0
C2	1,532	458	659	0	0
C3	6,001	464	698	0	0
C4	4,796	954	164	0	26
C5	1,269	266	522	0	0
C6	1,711	97	225	0	0
C7	1,220	294	420	0	0
C8	5,006	468	872	0	303
C9	0	0	0	0	0
C10	1,268	57	125	0	0
C11	228	1,202	372	0	0
C12	1,688	121	185	0	0
Improvement ratio needed	27.66 %	8.83 %	4.62 %	2.37 %	1.10 %

Unit: Million; A1–A10: the substitute name of bank, represent 10 "Old Commercial Banks"; B1–B16: the substitute name of bank, represent 16 "New Commercial Banks"; C1–C12: the substitute name of bank, represent 12 "Commercial Banks Upgraded from Credit Cooperatives"

Table 2 Decomposition of overall efficiency of commercial banks

Code of banks	Overall technical efficiency	Pure technical efficiency	Scale efficiency	Allocative efficiency	Return on scale
A1	1	1	1	1	C
A2	1	1	1	1	C
A3	0.8417	1	0.8417	0.9979	D
A4	1	1	1	1	C
A5	0.9850	1	0.9850	0.9944	D
A6	0.9423	1	0.9423	0.9996	D
A7	0.9900	1	0.9900	0.9999	D
A8	0.9724	0.9836	0.9886	0.9979	D
A9	0.9424	0.9438	0.9985	0.9917	D
A10	0.9869	0.9880	0.9989	1	D
B1	0.8684	0.8872	0.9788	0.9970	D
B2	0.8904	0.9844	0.9045	0.9978	D
B3	0.9176	0.9253	0.9917	0.9082	D
B4	1	1	1	1	C
B5	0.9344	0.9365	0.9978	0.9992	I
B6	1	1	1	1	C
B7	0.9551	0.9722	0.9824	0.9998	D
B8	0.9929	0.9985	0.9944	1	D
B9	0.9539	0.9557	0.9981	0.9999	D
B10	0.8138	0.8268	0.9843	0.9959	I
B11	0.7195	0.7387	0.9740	0.9252	I
B12	1	1	1	1	C
B13	1	1	1	1	C
B14	0.9387	0.9724	0.9653	0.9999	D
B15	0.9258	0.9276	0.9981	0.9986	I
B16	0.8782	0.9219	0.9526	0.9971	D
C1	0.9771	1	0.9771	0.9998	D
C2	0.9061	0.9066	0.9994	1	I
C3	0.8911	0.8963	0.9942	0.9999	I
C4	0.9562	1	0.9562	0.9426	I
C5	0.8624	0.913	0.9446	0.9964	I
C6	0.9260	0.9978	0.9280	0.9821	I
C7	0.7856	1	0.7856	0.9957	I
C8	0.9185	0.928	0.9898	0.9941	I
C9	1	1	1	1.0000	C
C10	0.9563	1	0.9563	0.9862	I
C11	0.8191	1	0.8191	0.9886	I
C12	0.9173	1	0.9173	0.9934	I

C constant return to scale, *D* decreasing return to scale, *I* increasing return to scale; A1–A10: the substitute name of bank, represent 10 "Old Commercial Banks"; B1–B16: the substitute name of bank, represent 16 "New Commercial Banks"; C1–C12: the substitute name of bank, represent 12 "Commercial Banks Upgraded from Credit Cooperatives"

Table 3 Efficiency comparison among three groups

Group	Efficiency	Mean	SD	Maximum	Minimum	Number
All	OE	0.9259	0.0744	1.0000	0.6657	38
	OTE	0.9333	0.0670	1.0000	0.7195	
	PTE	0.9633	0.0570	1.0000	0.7387	
	SE	0.9688	0.0477	1.0000	0.7856	
	AE	0.9915	0.0205	1.0000	0.9082	
Old Commercial Banks	OE	0.9743	0.0263	1.0000	0.9346	10
	OTE	0.9761	0.0249	1.0000	0.9417	
	PTE	0.9915	0.0178	1.0000	0.9438	
	SE	0.9845	0.0231	1.0000	0.9417	
	AE	0.9981	0.0029	1.0000	0.9917	
New Commercial Banks	OE	0.9149	0.0907	1.0000	0.6657	16
	OTE	0.9243	0.0776	1.0000	0.7195	
	PTE	0.9405	0.0726	1.0000	0.7387	
	SE	0.9826	0.0252	1.0000	0.9045	
	AE	0.9887	0.0283	1.0000	0.9082	
Commercial Banks Upgraded from Credit Cooperative	OE	0.9003	0.0618	1.0000	0.7822	12
	OTE	0.9096	0.0630	1.0000	0.7856	
	PTE	0.9701	0.0442	1.0000	0.8963	
	SE	0.9390	0.0698	1.0000	0.7856	
	AE	0.9899	0.0160	1.0000	0.9426	

OE overall efficiency, *OTE* overall technical efficiency, *PTE* pure technical efficiency, *SE* scale efficiency, *AE* allocative efficiency

4 Discussion

As efficiency is an important advantage for any kind of organizations, management will seek to pursuit most efficient way to utilize and allocate resources because of the resources scarceness. The increasing competition in banks industry, which is caused by the new entrants, may urge the “Old Commercial Banks” to seek more efficient way to run their business. The “Old Commercial Banks” has more experiences and resources in banks industry. They have plenty of industry-specific knowledge and know how to utilize their resources to create business and generate revenues. They also have strong relationships with clients and strong location advantages to access their customers, which are not easy for a new entrant to build up in a short period. Thus, the “Old Commercial Banks” may be more efficient in utilizing and allocating resources than the “New Commercial Banks”. But, the alternative argument indicates that from the standpoint of new entrants in banks industry, the “New Commercial Banks” with relative less resources than “Old Commercial Banks” are more capable of utilizing their resources in a more efficient and economical way because they are new in the industry and will consider and seek an efficient way to run business, which will provide them a new thought about how to utilize resources more efficiently and earn them asustainable advantage

Table 4 Efficiency comparison among the three groups Scheffe's test

Efficiency	Groups (I)	Groups (J)	Deviation of mean between two groups (I-J)	Standard deviation	p value
Overall efficiency	1	2	0.0594	0.028	0.124
		3	0.0739	0.030	0.060
	2	1	−0.0594	0.028	0.124
		3	0.0145	0.027	0.863
	3	1	−0.0739	0.030	0.060
		2	−0.0145	0.027	0.863
Overall technical efficiency	1	2	0.0517	0.025	0.142
		3	0.0664	0.027	0.062
	2	1	−0.0517	0.025	0.142
		3	0.0146	0.024	0.832
	3	1	−0.0664	0.027	0.062
		2	−0.0146	0.024	0.832
Pure technical efficiency	1	2	0.0510	0.022	0.080
		3	0.0213	0.023	0.658
	2	1	−0.0510	0.022	0.080
		3	−0.0296	0.021	0.370
	3	1	−0.0213	0.023	0.658
		2	0.0296	0.021	0.370
Scale efficiency	1	2	0.0018	0.018	0.994
		3	0.0455	0.019	0.067
	2	1	−0.0018	0.018	0.994
		3	0.0436	0.017	0.046
	3	1	−0.0455	0.019	0.067
		2	−0.0436	0.017	0.046
Allocative efficiency	1	2	0.0094	0.008	0.529
		3	0.0082	0.009	0.651
	2	1	−0.0094	0.008	0.529
		3	−0.0012	0.008	0.988
	3	1	−0.0082	0.009	0.651
		2	0.0012	0.008	0.988

Group 1: "Old Commercial Banks"; Group 2: "New Commercial Banks"; Group 3: "Commercial Banks Upgraded from Credit Cooperatives"

in resources allocation and utilization. Although the "New Commercial Banks" has relatively less customers and branches than the "Old Commercial Banks", they must put more endeavors to manage business and pursuit an efficient way to utilize resources in order to survive in more and fiercer competition environment. At the same time, although the "Old Commercial Banks" have advantages in the number of clients and more branches with better location, they run business in a relative traditional way, which may result in more "waste" in resources and hamper efficiency maximization. Likewise, the "Commercial Banks Upgraded from Credit Cooperatives" is originally local "Credit Cooperatives". Theyare also traditional financial institutions with old mindset in resources management. It may not easy for them to catch up with the efficiency of the “New Commercial Banks”. But they still have more strong relationship with clients and have plenty of knowledge about how to locate resources to generate revenues, which will make them have better efficiency value than the “New Commercial Banks”. Thus, we hypotheses that the mean efficiency value of the “Old Commercial Banks” and the mean efficiency value of the “Commercial Banks Upgraded from Credit Cooperatives” will be significantly different than that of “New Commercial Banks” and the hypotheses are supported in empirical analysis.

5 Conclusion

This study employs Data Envelopment Analysis to evaluate management efficiency of 38 commercial banks in Taiwan. The empirical results show as follows. First, we find that the “Old Commercial Banks” possess highest efficiency value than the other two groups. Both the “New Commercial Banks” and the “Commercial Banks Upgraded from Credit Cooperatives” have efficiency value below the average efficiency value of all subjects, which is different from the expectation that “New Commercial Banks” should have the highest efficiency value among all three groups. Only the average efficiency value of “Old Commercial Banks” is above the overall banks’ average. Besides, the “Old Commercial Banks” also have the highest overall technical efficiency, pure technical efficiency and allocative efficiency. It implies that the “Old Commercial Banks” are doing well in competing with the new entrants, which makes them keep better efficiency values than both the “New Commercial Banks” and the “Commercial Banks Upgraded from Credit Cooperatives”. Second, the results also indicate some directions for those “less-efficient” subjects to implement efficiency improvement. In order to raise the efficiency of banks, the top management of those banks with low efficiency value may refer to the allocation of resources and strategies application of those subjects with overall efficiency value of 1 and focus on the direction to restructure or reallocate their resources. And finally, according to Scheffe’s test, we find that the difference on overall efficiency was derived from the overall technical efficiency and scale efficiency because the mean overall efficiency, overall technical efficiency and scale efficiency of the “Old Commercial Banks” are all significantly larger than those of the “Commercial Banks Upgraded from Credit Cooperatives” at $\alpha = 0.1$ level. The mean pure technical efficiency of the “Old Commercial Banks” is significantly larger than that of the “New Commercial Banks” at $\alpha = 0.1$ level. Finally, the mean scale efficiency of the “New Commercial Banks” is significantly larger than that of the “Commercial Banks Upgraded from Credit Cooperatives” at $\alpha = 0.1$ level. As for the allocative efficiency, there is no significant difference among the three group at $\alpha = 0.1$ level.

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Probabilistic Evaluation of a Business Process Performance

Shin-Guang Chen

Abstract This paper proposes a probabilistic method to evaluation the performance of a business process in a company. A business process (e.g., order fulfillment process, commodity distribution process, etc.) comprises a network of value-added activities, performed by their relevant roles, to achieve the common business goal. A variety of methods are used to manage or improve process. Besides these advances, this paper proposes an innovative evaluation method of business process performance in terms of a simple Bayesian indicator. A numerical example is used to explain the proposed method.

Keywords Performance evaluation • Probability • Network reliability • Productivity

1 Introduction

A business process comprises a network of value-added activities, performed by their relevant roles (or staff/functions) or collaborators, to achieve the common business goal. Business Process Management includes methods, techniques, and tools to support the design, enactment, management, and analysis of business processes. Many valuable tools have been developed, such as Zachman Framework [1], IDS-Scheer ARIS [2] and Computer Sciences Corporation's Catalyst [3]. Analysts understand processes in terms of organizational coherence and business outcomes, and use a variety of methods to manage or improve process, including Six Sigma [4], TQM [5], Activity Based Costing [6], and reengineering [7]. Besides

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these remarkable advances, the performance evaluation for such a complicated business process is also important. This paper proposes an innovative evaluation method in terms of a simple Bayesian indicator from network analysis theory to evaluate the business process performance under role failures.

Network analysis [8] has received considerable interest in many areas. Examples of these areas are the computing systems [9], the information systems [10] and the computer networks [11]. For the area of business process modeling, Chen and Lin [12] have first applied network analysis theory in the performance evaluation of an enterprise resource planning system. Their results reveal some new directions in business process modeling and analysis. In network analysis, the network consists of edges and nodes to model a real life network. For example, modeling a business process is to express the roles in the process as nodes, and the precedence relationships between roles as links. Then, the work flows are moving through these roles. In practice, the roles are stochastic in nature. They have limited work capacity and may fail. Such a network with stochastic nodes is named stochastic-flow network [13]. The network performance (or reliability) is the probability that the maximal work flow of the network is no less than the demand d. Such performance can be calculated by means of minimal paths (MPs) [14] or minimal cuts (MCs) [15]. A path is a set of nodes whose existence results in the connection of source node and sink node. An MP is a path whose proper subset is not a path. A cut is a set of nodes whose removal results in the disconnection of source node and sink node. An MC is a cut whose proper subset is no longer a cut.

The remainder of the work is described as follows: The assumptions are presented in Sect. 2. Section 3 describes the process network model for a business process. A numerical example is subsequently illustrated in Sect. 4. Then, Sect. 5 draws the conclusion and comes to the discussions of this article.

2 Assumptions

Let $G = (A, B, M)$ be a process network where A is the set of links representing the precedence relationships between roles, $B = \{b_i | 1 \le i \le s\}$ is the set of nodes representing the roles in the process, and $M = (m_1, m_2, \ldots, m_s)$ is a vector with m_i (an integer) being the maximum capacity of b_i. Such a G is assumed to satisfy the following assumptions.

1. The capacity of b_i is an integer-valued random variable which takes values from the set $\{0, 1, 2, \ldots, m_i\}$ according to an empirical distribution function μ_i, which can be obtained by a statistical observation in a moving time frame. Note that the capacity 0 often means a failure or unavailability of this node.
2. The links are perfect. That is, they are excluded from the performance calculation.

3. Flow in G satisfies the flow-conservation law [8]. This means that the work flow started from the source node should be passed to the succeeding nodes and end at the sink node.
4. The states of working, failure or partial failure of nodes are independent from each other.

3 The Process Network Model

Suppose that an operation initiates the work flow from the source node through a set of alternative paths to the sink node to complete the business process. Let mp_1, mp_2, ..., mp_z be the MPs. Thus, the process network model can be described in terms of two vectors: the capacity vector $X = (x_1, x_2, \ldots, x_s)$ and the flow vector $F = (f_1, f_2, \ldots, f_z)$, where x_i denotes the current capacity of b_i and f_j denotes the current flow on mp_j . Then, such a vector F is feasible iff

$$\sum_{j=1}^{z} \left\{ f_j \middle| b_i \in mp_j \right\} \leq m_i \quad \text{for} \quad i = 1, 2, \ldots, s \tag{1}$$

Constraint (1) describes that the total flow through b_i can not exceed the maximum capacity of b_i. We denote such set of F as $U_M = \{F|F \text{ is feasible under } M\}$. Similarly, F is feasible under $X = (x_1, x_2, \ldots, x_s)$ iff

$$\sum_{j=1}^{z} \left\{ f_j \middle| b_i \in mp_j \right\} \leq x_i \quad \text{for} \quad i = 1, 2, \ldots, s \tag{2}$$

For clarity, let $U_X = \{F|F \text{ is feasible under } X\}$. The maximum flow under X is defined as $V(X) = \max \left\{ \sum_{j=1}^{z} \left\{ f_j \middle| F \in U_X \right\} \right.$

3.1 Probabilistic Performance Indicator

Given a demand d to represent the standard level of work flow, the probabilistic performance indicator R_d is the probability that the maximum flow is not less than d, i.e., $R_d = \Pr\{X|V(X) \geq d\}$. To calculate R_d, it is advantageously to find the minimum capacity vector in $\{X|V(X) \geq d\}$. A minimum capacity vector X is said to be a lower boundary point (LBP) for d iff (i) $V(X) \geq$ d and (ii) $V(Y) < d$, for any other vector Y such that $Y < X$, in which $Y \leq X$ iff $y_j \leq x_j$, for $j = 1, 2, \ldots, s$ and $Y < X$ iff $Y \leq X$

and $y_j < x_j$, for at least one j. Suppose there are totally t LBPs for d: $X_1, X_2, \ldots, X_t$, and $E_i = \{X|X \geq X_i\}$, the probability R_d can be equivalently calculated via the well-known inclusion-exclusion principle.

$$\begin{aligned} R_d &= \Pr\left\{X \middle| V(X) \geq d\right\} \\ &= \Pr\left\{\bigcup_{i=1}^{t} E_i\right\} \\ &= \sum_{k=1}^{t} (-1)^{k-1} \sum_{I \subset \{1,2,\ldots,t\},|I|=k} \Pr\left\{\bigcap_{i \in I} E_i\right\} \end{aligned} \tag{3}$$

where $\Pr\{\cap_{i \in I} E_i\} = \prod_{j=1}^{s} \sum_{l=\max\left\{x_{ij} \middle| \forall i \in I\right\}}^{m_j} \mu_j(l)$.

3.2 Generation of all LBPs for d

At first, we find the flow vector $F \in U_M$ such that the total flow of F equals d. It is defined as the following demand constraint.

$$\sum_{j=1}^{z} f_j = d \tag{4}$$

Then, let $\mathbf{F} = \{F|F \in U_M$ and satisfy Constraint (4)$\}$. If X is an LBP for d, then there is an $F \in \mathbf{F}$ such that

$$x_i = \sum_{j=1}^{z} \left\{f_j \middle| b_i \in mp_j\right\} \quad \text{for} \quad i = 1, 2, \ldots, \text{s} \tag{5}$$

This is a necessary condition for an LBP. Given an $F \in \mathbf{F}$, we generate a capacity vector $X_F = (x_1, x_2, \ldots, x_s)$ via Eq. (5). The set $\Omega = \{X_F \ |F \in \mathbf{F}\}$ is built. Let $\Omega_{min} = \{X|X$ be a minimum vector in $\Omega\}$. Then, Ω_{min} is the set of LBPs for d.

4 A Numerical Example

The company W is a distributor of a well-known detergent provider in Taiwan. W sells many kinds of detergents to the east Taiwan market. This process is initiated with a product inquiry from a customer to the teller in this company, who sends

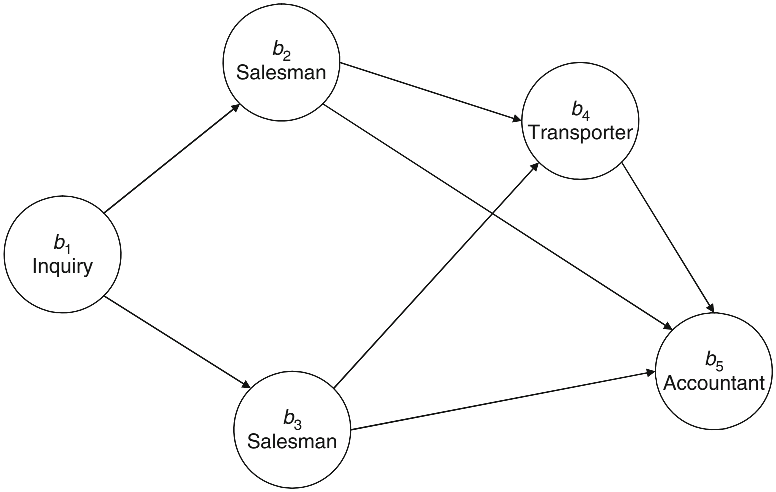

Fig. 1 A numerical example

Table 1 The throughputs of five roles sampled in a month

	The number of deliveries per 3 h						
The roles	0	1	2	3	4	5	6
b_1	1[a]	1	3	5	30	3	1
b_2	1	20	16	6	1	0	0
b_3	1	10	20	10	2	1	0
b_4	7	14	16	5	2	0	0
b_5	0	2	4	35	2	1	0

[a]The number of occurrences

the confirmed inquiry to one of the sales representatives to create orders for the inquiry. Then, the order is fulfilled by either the representatives themselves or another transporter. Finally, the order is closed by the accountant. Figure 1 shows the corresponding process network. The orders constitute the work flow in the process network, and confirm the flow-conservation law. Each path of work flow is a MP in the process network. Each node has capacity, which acts as a random variable, and may fail. The stochastic behavior of each node can be observed by the empirical distribution for a period of time. When the process starts, b_1 initiates the work flow and sends it via either b_2 or b_3 to b_4 or b_5, and b_4 sends it to b_5. Finally, b_5 ends the process. Therefore, the performance of such process network can be analyzed by the network reliability theory. The standard throughput level is four deliveries per 3 h for the entire process, and (4, 2, 2, 2, 4) is a standard throughput vector for each individual role respectively.

Table 1 gives the results of sampling from the throughputs of all five roles in a month. The statistical observation is done on every 3 h. The corresponding empirical distributions are shown in Table 2.

Table 2 The empirical distributions for the example

Distr. func.	The number of deliveries per 3 hours						
	0	1	2	3	4	5	6
μ_1	0.0227	0.0227	0.0682	0.1136	0.6818	0.0682	0.0227
μ_2	0.0227	0.4545	0.3636	0.1364	0.0227	0.0000	0.0000
μ_3	0.0227	0.2273	0.4545	0.2273	0.0455	0.0227	0.0000
μ_4	0.1591	0.3182	0.3636	0.1136	0.0455	0.0000	0.0000
μ_5	0.0000	0.0455	0.0909	0.7955	0.0455	0.0227	0.0000

Note: The red character signifies the significant value

There are four MPs found: $mp_1 = \{b_1, b_2, b_4, b_5\}$, $mp_2 = \{b_1, b_2, b_5\}$, $mp_3 = \{b_1, b_3, b_4, b_5\}$, $mp_4 = \{b_1, b_3, b_5\}$. All LBPs for four are generated step-by-step as follows:

Step 1. Find the feasible vector $F = (f_1, f_2, \ldots, f_4)$ satisfying both capacity and demand constraints.

(a) Enumerate f_j for $0 \le f_j \le 6$, $1 \le j \le 4$ do
(b) If f_j satisfies the following equations

$$f_1 + f_2 + f_3 + f_4 \le 6, f_1 + f_2 \le 6, f_3 + f_4 \le 6, f_1 + f_3 \le 6,$$
$$f_1 + f_2 + f_3 + f_4 = 4,$$

then $\mathbf{F} = \mathbf{F} \cup \{F\}$.
End enumeration.
The result is $\mathbf{F} = \{(0, 0, 0, 4), (0, 0, 1, 3), (0, 0, 2, 2), \ldots, (4, 0, 0, 0)\}$.

Step 2. Generate the set $\Omega = \{X_F \mid F \in \mathbf{F}\}$.

(a) For $F = (0, 0, 0, 4)$ in F do
(b) $x_1 = f_1 + f_2 + f_3 + f_4, x_2 = f_1 + f_2, x_3 = f_3 + f_4, x_4 = f_1 + f_3,$ $x_5 = f_1 + f_2 + f_3 + f_4.$
(c) $U_X = U_X \cup \{X_F = (4,0,4,0,4)\}$.
End for-loop.
(d) For $X = (4, 0, 4, 0, 4)$ in U_X do
(e) If $X \notin \Omega$, then $\Omega = \Omega \cup \{X = (4, 0, 4, 0, 4)\}$.
End for-loop.
At the end of the loop: $\Omega = \{X_1 = (4, 0, 4, 0, 4), X_2 = (4, 0, 4, 1, 4), \ldots, X_{25} = (4, 4, 0, 4, 4)\}$.

Step 3. Find the set $\Omega_{min} = \{X \mid X$ is a minimum vector in $\Omega\}$ via pairwise comparison.

The result is $\Omega_{min} = \{X_1 = (4,0,4,0,4), X_6 = (4,1,3,0,4), X_{10} = (4,2,2,0,4), X_{13} = (4,3,1,0,4), X_{15} = (4,4,0,0,4)\}$.

Finally, the probability R_4 can be calculated in terms of 5 LBPs. Let $E_1 = \{X|X \geq X_1\}$, $E_2 = \{X|X \geq X_6\}$, $E_3 = \{X|X \geq X_{10}\}$, $E_4 = \{X|X \geq X_{13}\}$ and $E_5 = \{X|X \geq X_{15}\}$. From Eq. (3), we get $R_4 = \Pr\{\cup_{i=1}^{5} E_i\}$.

Then, by applying the inclusion-exclusion rule,

$$\begin{aligned} R_4 &= \Pr\left\{\bigcup_{i=1}^{5} E_i\right\} \\ &= \sum_{k=1}^{5} (-1)^{k-1} \sum_{I \subset \{1,2,\ldots,5\}, |I|=k} \Pr\left\{\bigcap_{i \in I} E_i\right\} \\ &= 0.0296808 \end{aligned}$$

In this example, R_4 is 0.0296808, a very low probability for the business process to achieve the demand of four deliveries per 3 h. Inspecting Table 2, one can identify that two roles, b_2 and b_5, are lagged by compared with the standard throughputs, (2) and (4).

5 Conclusion and Discussions

This article proposes a novel method using Bayesian indicator to evaluate the performance of a business process by integrating each role's performance which may suffer failures, partial failures, or be reserved by the other process. Many valuable analyses can be conducted based on this indicator. For example, this paper shows how to identify the lagged roles in the process. In general, the proposed simple probabilistic indicator provides a new powerful tool in business process management activities. The realtime and precise adjustment of business process activities becomes possible.

Future researches are encouraged on investigating multi-commodity business process, or cyclic business process. Both kinds of business process networks are common in our real life networks.

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A Study of Risk and Performance Evaluation in Taiwanese Semiconductor Industry

Jau-shin Hon, Hui-ling Lin, and Ling-ya Su

Abstract This study discusses the relationship between risk and performance of the sampling of 12 Taiwanese semiconductor companies during the period of financial crisis. The purpose of this study is to survey the risk response capabilities of upstream and downstream of Taiwanese semiconductor firms. The methods of data envelopment analysis (DEA) and Malmquist index are applied to analyze the industry operating efficiency. From the viewpoint of efficiency, this study contributes to the company operation performance assessment before and after the period of financial crisis.

Keywords Data envelopment analysis • Malmquist productivity index • Risk and return

1 Introduction

Given the debate of whether only traditional evaluation methods remain appropriate for monitoring firms' performance, this study aimed to develop a new performance evaluation method to deal with this issue. We used Taiwanese semiconductor firms' financial profitability to justify the smile curve. Then, Data envelopment analysis (DEA) has been used to solve the changing situation of efficiency. DEA techniques were used by accommodating financial measures and time was considered as inputs/outputs variables providing a metric for industry and firm performance measurement [1, 2]. More specifically, several studies have used DEA techniques in order to measure industry performance.

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To solve some problems concerning performance evaluation, this study uses several methods other than DEA such as risk and return, and Malmquist productivity index [3, 4]. In contrast to prior studies, this paper for the first time uses several new models combining multiple performance measurements to evaluate the performance during the period of economy crisis. In such a way we provide an illustration of how financial indexes can be combined into a performance measure producing appropriate results. Using financial data the paper measures the performance of Taiwanese semiconductor sectors providing empirical evidences of the influence of performance evaluation.

2 Literature Review

2.1 Risk Evaluation

The traditionally accepted definition of risk is the potential for realization of unwanted, negative consequences of an event. For an event to be considered as a source of risk there must be a reasonable predictable loss associated which arises as a consequence of this chance event [5]. The scale of the loss referred to as the risk impact and attempts to place an acceptable value on this loss, often in monetary terms. For a firm the impact of the incidence of almost every risk event can be measured in financial terms as the effect upon turnover, market share, and profitability.

In order to investigate the effectiveness of these firms, we utilize Data Envelopment Analysis-window analysis models to evaluate the relative efficiencies of 12 semiconductor firms' financial data in 2008.

2.2 Efficiency Theory

Farrell [6] developed input-based indices of technical efficiency measured as the maximum equiproportionate reduction in all inputs consistent with equivalent production of observed output. As pointed out by Fare and Lovell [7], however, some slack may remain in some but not all inputs and/or outputs after Farrell efficiency is achieved. As a result, the Farrell measure may not measure Koopmans efficiency. Interest in this early theoretical work on technical inefficiency was renewed in the late 1970s with the development of Data Envelopment Analysis (DEA), a Farrell-based mathematical programming approach to frontier calculation pioneered in Charnes et al. [8]. DEA envelops the observed data to determine a best practice frontier. This technique has become popular in evaluating technical efficiency because it easily handles multiple outputs, is non-parametric, and does not require input price data.

The DEA is a mathematical programming approach which assesses the comparative efficiency of a set of decision making units (DMU), where the presence of multiple inputs and outputs makes comparison difficult. The DEA is a non-parametric approach which allows efficiency to be measured without any assumptions regarding the functional form of the production function or the weights for the different inputs and outputs chosen. The DEA defines a best practice efficiency frontier that can be used. In economic study, DEA is also a powerful tool when studying boundary productions which have multiple inputs and multiple outputs. Therefore, it can be used to research the problems which are relevant with multilateral production function, such as the rate of technological progress, the productivity index, scale, the minimum cost problem and maximum benefits, etc. Since the DEA method does not need to estimate parameters in advance, it has underestimated superiority in avoiding subjective factors, simplifying operations and reducing error, etc. Compared with other methods, the biggest advantage of DEA method is that it is pure technical, need not given an advance known production function with the parameters.

Three main DEA models have been developed according to the nature of returns to scale: the CCR model, the BCC model, and Malmquist indexes. The CCR model, named for Charnes et al. [8], was developed under the assumption of constant returns to scale (CRS). The second model, the BCC model, introduced by Banker et al. [9] as an extension of the CCR model, was developed under the assumption of variable returns to scale (VRS). VRS implies disproportionate variation in outputs when inputs are increased. This model is able to measure pure technical efficiency, while scale efficiency can be determined by overall performance efficiency divided by pure technical efficiency. This enables the decision makers to determine whether the inefficiency comes from a technical problem or from a scale problem.

Malmquist indexes can be used to describe the production technology efficiency which is intertemporal with multiple inputs and outputs variables and determine the changes of total factor productivity. Malmquist index analysis has the following three advantages: First, it is suitable for multiplt countries or regions across the stage to analyze sample. Second, it can be further decomposed into Technical Efficiency Change and Efficiency Change index. Third, it does not need relative price information of factors. So this paper also adopts the Malmquist index method. The analysis equation is as follows.

3 Methodology

3.1 Sample

High-tech industries can be defined as those that normally invest at least 10 % of their sales in R&D [10]. This study examines the semiconductor industry in Taiwan. This industry can be classified as a high-tech industry. The semiconductor

Table 1 Taiwanese semiconductor industry productivity (2006–2010)

	Effch	Techch	Pech	Sech	Tfpch
2006–2007	1.089	1.139	0.988	1.102	1.240
2007–2008	0.874	0.438	0.906	0.965	0.383
2008–2009	0.988	0.979	0.967	1.021	0.967
2009–2010	1.217	0.991	1.197	1.017	1.206
Mean	1.034	0.834	1.009	1.025	0.862

Note: the index > 1 means progression; otherwise, regression

industry is selected as the empirical sample because it exhibits typical features of high-tech industries, including steep price erosion and stress due to the rapid progress of technology. The Standard Industry Classification (SIC) code of firms that produce semiconductors and related devices is 3675. The industry classification system is based on the US-based SIC, which was created by the US government (1994).

The original observations of 12 firms were matched with firm-level data from the Taiwan Economic Journal, which annually compiles a list of firms' financial reports. These lists are well received in the professional economic and financial communities and various indexes of these surveys have been used to support numerous research projects [11, 12]. The 12 firms ranked by company assets were extracted from 2006 to 2010 [13]. This final dataset consisted of 12 valid firms from the following semiconductor sub-families: Integrated- Circuit (IC) design firms, IC fabrication firms, IC packaging firms, and IC testing firms.

3.2 Data

The data selected for this paper is related to the input and output of the industrial enterprises' operation expense. The inputs of operation overhand are primarily R&D expenditure, fixed assets, operational expenditure and R&D personnel which are four core indexes in science and technology activities. The outputs of operation activities of semiconductor firms are selected from many indexes including operation revenues and operation gross profit.

3.3 Malmquist Productivity Index

This study decomposed the Malmquist productivity (**tfpch**) index into four sources of productivity change: technical efficiency change (**effch**), technical change (**techch**), pure efficiency change (**pech**) and scale efficiency change (**sech**). Table 1 shows every pair of adjacent year's values for each variable such as **effch**, **techch**, **pech**, **sech** and **tfpch** (total factor productivity change).

The major objective is to find out the key influencing index; furthermore, it leads to improve the productivity. The empirical results summarized in Table 1. The total factor productivity change index exhibits the regression trend during the period of research. The major reason is the technical change less than one. It means the Taiwanese semiconductor industry is in maturity stage and does not create new technology. Although at different levels of financial crisis, the relationship of productivity change and technical change is positive. It means that the technical development of Taiwanese semiconductor industry is weak. This result suggests that the high-tech firms need consistent investing the new productivity equipment, R&D resource, and new patent to maintain the competitive advantage.

4 Results

In the analysis of performance measurement there is a practical limitation to the number of ratios which can be included. Increasing the number of ratios for predictive purposes introduces redundancies in the analysis and makes the interpretation of the results increasingly difficult. We utilize DEA and Malmquist index to implement performance evaluations in semiconductor industry for Taiwanese 12 firms based on Taiwan Economic Journal. We employ four inputs and two outputs in our analysis.

IC design industry has a higher proportion of research and development (R&D) costs and lower operating costs; IC manufacturing, packaging and testing industries have a higher proportion of permanent assets and operating costs. IC manufacturing, packaging and testing industries burden higher operating and financial risks, and the operating profit of the manufacturers is significantly influenced by the economy cycle.

IC design industry has less risk during the period of financial crisis in the 2008, but they invest lots of R&D to improve their performance. Comparing to IC design firms, IC manufacturing firms only invest the IC equipment before the financial crisis coming. It occur the idle capacity and the investment becomes a major burden, so it decreases the operating efficiency; meanwhile, IC packaging and testing industries since the operating income decreasing, it results increasing operating costs. Therefore, the decreasing of operating profits makes them to be relatively inefficient units during the economy crisis.

Most IC design firms are in the low risk-high reward region which is the best position in the smile curve. However, only a small number of IC manufacturing, packaging and testing firms are in this best region. It shows the risk can be circumvented by management.

The productivity of Taiwan's semiconductor industry is mainly reasoned from the growth rate of technological progress. In order to maintain the advantage in this competitive field, the semiconductor firms should actively develop the new technology and strengthen the patent blueprint.

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Water Flow-Like Optimization Algorithm for Multi-objective Continuous Optimization Problem

Feng-Cheng Yang and Bryan Ni

Abstract This paper presents a WFA for Multi-objective Continuous Optimization Problems. Namely WFA4MC. In order to prove WFA4MC performances precisely, this research proposes Correctness and Coverness to measure non-dominated solutions in ZDT functions. Besides, the Generational Distance is used in the comparison with other heuristic algorithms. The result showed that based on the same limit of the number of objective function calls, the WFA4MC outperform than others.

Keywords Correctness • Multi-objective continuous optimization problem • ZDT functions

1 Introduction

Multiple-Objective continuous optimization problem has been applied in widely many fields such as science, engineering and management. However, solving such problem is regarded as a challenge because of the high dimensionality and complex objectives. Some heuristic-based methods capable with dealing such difficulties have been developed such as AMOPSO [1], NSGAII [2] and MOEPSO [3]. Such kind of methods has constant number of solution agent. For these methods, once the solutions tend to converge during the searching process, redundant computation is arisen.

This paper proposed a novice approach, i.e. Water Flow-like Algorithm for Multi-objective Continuous Optimization Problems (WFA4MC). This approach tactically adjusts the solution agent number for efficient search and is based

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on Water Flow-like Algorithm (WFA) proposed by Yang and Wang [4]. WFA mimics the water flow traversing on the terrain with regard to several phenomena such as flow moving, flow splitting, evaporation and precipitation. Single water corresponds to a solution agent and the terrain is related to the solution space. A single moving water flow represents searching behavior of a solution agent. Flow splitting increases the solution agent number to intensify the searching direction and computation. While flow merging decreases the solution agent number to remove the resemble solutions. Evaporation decreases the solution agent number for the removal of weak solution. When the air is saturated with water, precipitation starts. Additional solution agents are generated for random search.

Evaluation of non-dominant solutions in a proper manner is another issue. Generational distance proposed by Zitzler et al. [5] is commonly in use for measuring the Euclidean distance between current obtained non-dominant solution and the true optimal p solution.

However, Generation distance does not provide the information that how well the non-dominant solutions are not dominant by Pareto-front solution Also it cannot detect the solutions narrowly distributed in Pareto front. This paper further proposed two more performance indices, i.e. Correctness and Coverness. Correctness evaluates how many current obtained non-dominant solutions are not dominant from true optimal non-dominant solutions. Coverness quantifies how well the current-obtained non-dominant solutions cover the true optimal non-dominant solutions.

2 Multi-objective Continuous Optimization Problem

Assume that a solution to the multi-objective optimization problem consists of p indexed real numbers and is defined as a p-dimensional vector $\mathbf{x} = [x_1 x_2 \cdots x_p]$. Each variable is bounded by given lower and upper limits, such that $\underline{x}_k \leq x_k \leq \overline{x}_k$; $x_k, \underline{x}_k, \overline{x}_k \in \mathbb{R}$, $\forall\, k \in \{1{,}2, \ldots, p\}$. Suppose that there are g objective functions defined for the problem: $f_j(\mathbf{x}) : \mathbb{R}^p \rightarrow \mathbb{R}; j = 1, 2, \cdots, g$. Objective values of the solution $\mathbf{x}$ can be denoted by a g-dimensional vector $\mathbf{f} = [f_1 f_2 \cdots f_g] \equiv [f_1(\mathbf{x}) f_2(\mathbf{x}) \cdots f_g(\mathbf{x})]$. The goal of this optimization problem is to either maximize or minimize these objective values.

Instead of providing an optimal solution, a set of non-dominated solutions are usually presented to the user for a multi-objective optimization problem. Let the set be $\widehat{X}$. Without loss of generality, assume that the goal of the optimization problem is to minimize all objective values. Therefore, for a pair of non-dominated solutions $\mathbf{x}^i$ and $\mathbf{x}^{i'}$, $\mathbf{x}^i, \mathbf{x}^{i'} \in \widehat{X}$, there is at least one component j such that $f_j^i < f_j^{i'}$, where $\mathbf{f}^i = [f_1^i f_2^i \cdots f_g^i] \equiv [f_1(\mathbf{x}^i)\ f_2(\mathbf{x}^i) \cdots f_g(\mathbf{x}^i)]$ and $\mathbf{f}^{i'} = \left[f_1^{i'} f_2^{i'} \cdots f_g^{i'}\right] \equiv \left[f_1\left(\mathbf{x}^{i'}\right)\ f_2\left(\mathbf{x}^{i'}\right) \cdots f_g\left(\mathbf{x}^{i'}\right)\right]$ are their objective vectors respectively. In other words, non-dominated solutions should mutually have at least one objective value superior than that of others. Let operation Dominated$\left(\mathrm{X}^i, \mathrm{X}^{i'}\right)$ be used to test whether the first solution, $\mathbf{x}^i$, is dominated by the second one, $\mathbf{x}^{i'}$. Then

$$\text{Dominated}\left(\mathrm{X}^i, \mathrm{X}^{i'}\right) = \begin{cases} \text{false, if } \exists j \in \{1, 2, \ldots, g\} \ni f_j^i < f_j^{i'} \\ \text{true, otherwise} \end{cases} \tag{1}$$

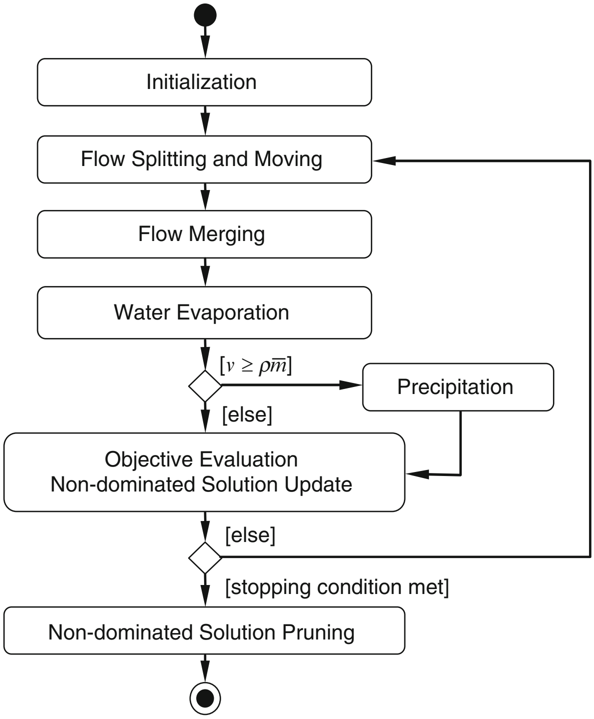
When a candidate solution $\mathbf{x}^i$ is considered for joining the non-dominated solution set $\widehat{X}$, it will be subject to this domination test against all solutions in the set. Once the solution is not dominated by any solution in the set, it is recognized as a new member of the set.

Although, it seems that we can provide as many as non-dominated solutions to the user for decision making, people prefers a finite number of solutions for easier application. Therefore, suppose $\overline{s}$ is the required number of non-dominated solution in $\widehat{X}$ and s is the number of solutions in $\widehat{X}$. When $s > \overline{s}$, $s - \overline{s}$ "inferior" solutions should be expelled from $\widehat{X}$. Moreover, the objective vectors $\mathbf{f}$ of the solutions in $\widehat{X}$ are expected to cover the objective space as large as possible to provide a wider spectrum for decision making. This means the $\overline{s}$ non-dominated solutions should be separated far from each other on the objective space. A solution with smaller distances to its neighbors on the solution space is then regarded as inferior one, which is a candidate for solution pruning. We propose a pruning method that sorts the solutions in $\widehat{X}$ with a jamming distance. The $s - \overline{s}$ solutions with smaller jamming distances are pruned away; details will be given later.

3 WFA Model for the Continuous Multi-objective Optimization Problems

The developed computation model based on the water flow like algorithm consists of a set of water flows represented by their locations, $X = \{\mathbf{x}^1, \mathbf{x}^2, \cdots, \mathbf{x}^n\}$, where n is the number of flows of the current flow set X. The location of flow i is $\mathbf{x}^i = [x_1^i \; x_2^i \cdots x_p^i]$, representing a solution to the optimization problem. For easier presentation, hereafter we alternatively use index i or location $\mathbf{x}^i$ to refer to a flow. The set of water flows is then recursively subject to a serial of water flow operations to yield a new set of flows to enhance the objective values of the solutions represented by their locations. Note that the set of flows X is updated both in the number of flows and their locations, subjecting to water splitting and merging operations. The flow splitting operation on a flow depends on the objective enhancement of the current location with respective to its previous location. Therefore, a virtual parent flow with location $\tilde{\mathbf{x}}^i = \left[\tilde{x}_1^i \tilde{x}_2^i \cdots \tilde{x}_p^i\right]$ is defined for flow i. Chronically, $\tilde{\mathbf{x}}^i$ can be regarded as the previous location of flow i. When more than one sub flow is split, these sub flows share the same parent. Let $\mathbf{f}^i = [f_1^i f_2^i \cdots f_g^i]$ and $\tilde{\mathbf{f}}^i = \left[\tilde{f}_1^i \tilde{f}_2^i \cdots \tilde{f}_g^i\right]$ be the vectors of objective values of flow i and its parent, respectively. In addition to the location and objective values, a mass property m^i is

Fig. 1 The computation flow of the proposed WFA for multi-objective optimization problems



defined for flow i, which is used to determine whether a flow survives to the next flowing iteration and to regulate the precipitation operation.

For final optimal solution presentation, a non-dominated solution set is constructed, which is denoted by $\widehat{X} = \{\widehat{\mathbf{x}}^1, \widehat{\mathbf{x}}^2, \cdots, \widehat{\mathbf{x}}^s\}$, where s is number of non-dominated solutions found. Each solution in $\widehat{X}$ is cloned from the set of flows in X after exclusive domination tests.

Figure 1 illustrates the computation flow of the presented WFA for Multi-objective Continuous Optimization Problems. Notice that several stopping conditions can be provided and specified by the user to stop the solution evolution. In our model, iteration limits, elapsed CPU execution time, and number of objective evaluations are provided to stop the solution evolution.

3.1 Initialization

Initially, only one flow is defined in the flow set; i.e., $n = 1$ and $X = \{\mathbf{x}^1\}$. Let $m^1 = \overline{m}$, where $\overline{m}$ is a user specified mass that will regulate flow splitting. Components of location $\mathbf{x}^1$ are randomly set by

$$x_k^1 \leftarrow\sim U(0,1)(\overline{x}_k - \underline{x}_k) + \underline{x}_k, k = 1, 2, \cdots, p$$

where $\sim U(0,1)$ is a uniformly distributed random real value bounded within [0,1]. Since the initial flow is not split from any other flow, we randomly assign the location of its parent flow $\tilde{\mathbf{x}}^1$ as

$$\tilde{x}_k^1 \leftarrow\sim U\,(0,1)\,(\overline{x}_k - \underline{x}_k) + \underline{x}_k, k = 1, 2, \cdots, p$$

The objective vectors $\mathbf{f}^1 = [f_1^1 f_2^1 \cdots f_g^1]$ and $\tilde{\mathbf{f}}^1 = \left[\tilde{f}_1^1\,\tilde{f}_2^1 \cdots \tilde{f}_g^1\right]$ of both locations (solutions) $\mathbf{x}^1$ and $\tilde{\mathbf{x}}^1$ are then evaluated and solution domination test is conducted to constitute the initial non-dominated solution set. Therefore,

$$\widehat{X} = \begin{cases} \{\mathbf{x}^1\}, \text{if Dominated}\left(\tilde{\mathbf{x}}^1, \mathbf{x}^1\right) = \text{true} \\ \{\tilde{\mathbf{x}}^1\}, \text{else if Dominated}\left(\mathbf{x}^1, \tilde{\mathbf{x}}^1\right) = \text{true} \\ \{\tilde{\mathbf{x}}^1, \mathbf{x}^1\}, \text{otherwise} \end{cases} \tag{2}$$

The amount of objective improvement influences the flow moving and flow splitting, both in the location change and the number of sub flows split. To evaluate the amount of objective value improvement, the largest and smallest values of each objective value obtained so far are updated and recorded during the water flowing operation. Let $\underline{f}_j$ and $\overline{f}_j$ be the smallest and largest values of objective values $f_j(\mathbf{x})$ obtained so far. Therefore, initially

$$\underline{f}_j = \min\left(f_j^1, \tilde{f}_j^1\right); j = 1, 2, \cdots, g \tag{3}$$

and

$$\overline{f}_j = \max\left(f_j^1, \tilde{f}_j^1\right); j = 1, 2, \cdots, g \tag{4}$$

The j-th objective value of water flow i can be normalized as

$$f'^i_j = \frac{f_j^i - \underline{f}_j}{\overline{f}_j - \underline{f}_j} \tag{5}$$

In addition, since there are g objective values, a weighted sum of objective value F^i is defined for flow i as

$$F^i = \sum\nolimits_{j=1}^{g} w_j f'^i_j = \sum\nolimits_{j=1}^{g} w_j \frac{f_j^i - \underline{f}_j}{\overline{f}_j - \underline{f}_j} \tag{6}$$

where w_j is a user specified weight for objective function $f_j(\cdot)$. Similarly, the weighted objective value of the parent flow of flow i is

$$\tilde{F}^i = \sum\nolimits_{j=1}^{g} w_j \frac{\tilde{f}_j^i - \underline{f}_j}{\overline{f}_j - \underline{f}_j} \tag{7}$$

We let the amount of objective improvement determine the number of sub flows in the operation of flow splitting. To help evaluating the improvement, an improvement threshold θ is defined in our WFA model. When the objective improvement of a flow exceeds the threshold, no flow splitting is executed. The threshold is defined as the average of the difference between weighted objective values of all flows and their parents; i.e.,

$$\theta = \frac{\Delta F}{N} \tag{8}$$

where N is the total number of flows constructed so far and ΔF is cumulated objective differences of these flows. Initially

$$\Delta F = \left|F^1 - \tilde{F}^1\right| \text{ and } N = 1 \text{ since } X = \left\{\mathbf{x}^1\right\} \tag{9}$$

3.2 Flow Splitting and Moving

Flow splitting and moving operation is sequentially conducted for each flow in the current flow set X. Firstly, the objective value improvement for each flow is evaluated to determine the number of sub flows. Once the number is determined, the location advancements of all sub flows follow to create sub flows. The number of sub flows split from a flow is restricted by a split limit $\overline{n}$, whose value is set by the user to avoid an exponentially increased number of flows. In general, a smaller improvement amount of objective value is designated to split more sub flows for a wider solution exploration. On the other hand, a larger amount should bind the same flow for neighborhood exploitation. Therefore, we define the number of sub flows split from flow i as

$$n^i = \begin{cases} 1, \text{if } \left|\tilde{F}^i - F^i\right| > \theta \\ \text{Round}\left(\text{Pow}\left(\overline{n}, \left(1 - \dfrac{\left|\tilde{F}^i - F^i\right|}{\theta}\right)\right)\right), \text{otherwise} \end{cases} \tag{10}$$

Assume that $\mathbf{x}_1^i, \mathbf{x}_2^i, \cdots, \mathbf{x}_{n^i}^i$ are locations of the n^i sub flows split from flow i and

$$\mathbf{x}_q^i = \left[x_{q1}^i \ x_{q2}^i \cdots x_{qp}^i\right], q = 1, 2, \cdots, n^i \tag{11}$$

Where

$$\underline{x}_k \le x_{qk}^i \le \overline{x}_k, k = 1, 2, \cdots, p \tag{12}$$

For a multi-objective optimization problem, the solution evolution is a forwarding process toward non-dominated solutions. Locations of the sub flows split from flow i are stochastically determined by the corresponding variables of flow i, parent flow of flow i, and a randomly selected flow from the non-dominated set. For each sub flow, a referential non-dominated solution is randomly selected first. Let location vector $\widehat{\mathbf{x}}^{i'}$ be the selected non-dominated solution for a sub flow of flow i, where $i' = \text{RandomInteger}(1, m)$.

Note that RandomInteger(*min*, *max*) returns a random integer that follows uniform distribution between integers *min* and *max*.

The value of the k-th variable x^i_{qk} is then set stochastically with respective to a target value ξ that is selected from the k-th component of either $\mathbf{x}^i$, $\tilde{\mathbf{x}}^i$, or $\widehat{\mathbf{x}}^{i'}$. If flow i has a clone in the non-dominated solution set $\widehat{X}$, ξ is directly selected from $\mathbf{x}^i$. Otherwise, if the parent flow is a non-dominated solution ξ is selected from $\tilde{\mathbf{x}}^i$, since flow i is inferior to its parent. On the other hand, if both $\mathbf{x}^i$ and $\tilde{\mathbf{x}}^i$ are not non-dominated solutions, $\widehat{\mathbf{x}}^{i'}$ is targeted. Therefore,

$$\xi = \begin{cases} x^i_k, \text{if } \mathbf{x}^i \in \widehat{X} \\ \tilde{x}^i_k, \text{else if } \tilde{\mathbf{x}}^i \in \widehat{X} \\ \widehat{x}^{i'}_k, \text{othewise} \end{cases} \tag{13}$$

Value of x^i_{qk} is then stochastically set to the target ξ or a random value bounded by $\left[\underline{\xi}, \overline{\xi}\right]$ with an equal probability. Bounds

$$\underline{\xi} = \begin{cases} \frac{1}{2}\left(\underline{x}_k + \xi\right), \text{if } \xi = \widehat{x}^{i'}_k \\ \max\left(\underline{x}_k, \xi - \left|\xi - \widehat{x}^{i'}_k\right|\right), \text{otherwise} \end{cases} \tag{14}$$

$$\overline{\xi} = \begin{cases} \frac{1}{2}\left(\overline{x}_k + \xi\right), \text{if } \xi = \widehat{x}^{i'}_k \\ \min\left(\overline{x}_k, \xi + \left|\xi - \widehat{x}^{i'}_k\right|\right), \text{otherwise} \end{cases} \tag{15}$$

Note that bounds $\underline{\xi}$ and $\overline{\xi}$ are constrained by the given coordinate bounds $\underline{x}_k$ and $\overline{x}_k$, as well as the target value ξ and $\widehat{x}^{i'}_k$. The reduced bounds are then used to generate location values centering around ξ. Therefore,

$$x^i_{qk} = \begin{cases} \xi, \text{if} \sim U(0,1) \le 0.5 \\ \text{RandomReal}\left(\underline{\xi}, \overline{\xi}\right), \text{otherwise} \end{cases} \tag{16}$$

Where RandomReal(*min*,*max*) returns a uniformly distributed random real value bounded by *min* and *max*. Note that the location vectors of all sub flows are sequentially determined while the component values are determined one after the other.

The last step in flow splitting is to distribute the mass to sub flows and assign their parents. Two types of mass distribution are provided. Each type is dedicated to a type of flow merging operation. Our WFA for multi-objective optimization problems presents two types of flow merging: one is based on the closeness of flow locations and the other is on the similarity of objective values.

The first type of mass distribution evenly distributes the mass to all the sub flows. Let m_q^i be the mass of the q-th sub flow split form flow i; then

$$m_q^i = \frac{1}{n^i} m^i, q = 1, 2, \cdots, n^i \tag{17}$$

The second type of mass distribution requires that the objective values of all sub flows must be evaluated first. Assume that the objective vector of the q-th sub flow split form flow i is

$$\mathbf{f}_q^i \equiv \left[f_1\left(\mathbf{x}_q^i\right) \cdots f_g\left(\mathbf{x}_q^i\right) \right] = \left[f_{q1}^i \;\; f_{q2}^i \cdots f_{qg}^i \right] \tag{18}$$

and the weighted sum of objective value is

$$F_q^i = \sum\nolimits_{j=1}^{g} w_j \frac{f_{qj}^i - \underline{f}_j}{\overline{f}_j - \underline{f}_j}, q = 1, 2, \cdots, n^i \tag{19}$$

Notice that the largest and smallest objective values, $\overline{f}_j$ and $\underline{f}_j$, are updated before evaluating the objective values of all sub flows. The amount of mass received by a sub flow is proportional to the amount of objective improvement from its parent; e.g., $F^i - F_q^i$ for the q-th sub flow. Notice that the amount of improvement might be negative. We let the sub flow with the largest improvement receive twice the mass of the one with the lowest. Therefore for sub flows split from flow i, the largest and smallest objective improvements are determined first by

$$\overline{\delta} = \max_{q=1,2,\cdots,n^i} \left\{ F^i - F_q^i \right\} \tag{20}$$

and

$$\underline{\delta} = \min_{q=1,2,\cdots,n^i} \left\{ F^i - F_q^i \right\} \tag{21}$$

The relative portion of mass splitting for the q-th sub flow is

$$\rho_q = \left(F^i - F_q^i - \underline{\delta}\right) + \left(\overline{\delta} - \underline{\delta}\right) \tag{22}$$

The mass received by the q-th sub flow form flow i is

$$m_q^i = \frac{\rho_q}{\sum_{q'=1}^{n^i} \rho_{q'}} m^i, q = 1, 2, \cdots, n^i \tag{23}$$

After the mass is distributed, the location, objective values, and weighted objective value of flow i are then assigned as parent attributes of the split sub flows; i.e.,

$$\left.\begin{aligned} \tilde{\mathbf{x}}_q^i &\leftarrow \mathbf{x}^i \\ \tilde{\mathbf{f}}_q^i &\leftarrow \mathbf{f}^i \\ \tilde{F}_q^i &\leftarrow F^i \end{aligned}\right\} q = 1, 2, \cdots, n^i$$

Notice that if $n^i = 1$, flow i is regarded as being transformed into its single sub flow that is subject to location moving, objective evaluation, and parent change, etc.

Finally, a new set of flows constructed from sub flows is yielded as

$$X \leftarrow \bigcup_{i=1}^{n} \left\{\mathbf{x}_1^i, \mathbf{x}_2^i, \cdots, \mathbf{x}_{n^i}^i\right\}$$

and the new number of flows is

$$n \leftarrow \sum_{i=1}^{n} n^i$$

3.3 Flow Merging

The flow merging operation conducted in the WFA is to eliminate duplicated solution agents to avoid unnecessary solution searches and evaluations. The location-based merging approach is frequently adopted in general optimization problems, either continuous or discrete ones. In addition to the location-based approach, we propose an objective-based merging approach for our multi-objective optimization problems, where a set of non-dominated solutions with objective values dispersedly distributed in the objective space is preferred.

Two flows will be merged in the location-based merging operation when the locations of two flows are close enough. A Location Closeness Factor β_L, $0 < \beta_L < 1$, is defined to facilitate the merging operation. Ifthe normalized component variable differences of two flows are all smaller than the factor, they are eligible for merging. Let LocationMergeable($\mathbf{x}^i$, $\mathbf{x}^{i'}$) be used to identify whether flow i can be merged with i';

$$\text{LocalMergeable}\left(x^i, x^{i'}\right) = \begin{cases} \text{false, if } \exists k \in \{1, 2, \cdots, p\} \ni \frac{\left|x_k^i - x_k^{i'}\right|}{\overline{x}_k - \underline{x}_k} > \beta_L \\ \text{true, otherwise} \end{cases} \tag{24}$$

On the other hand, when objectives of two flows on the objective space are close enough, they can be merged to increase the spread of non-dominated solutions on the objective space. Let β_O, $0 < \beta_O < 1$ be the *Objective Closeness Factor*, which is used for objective-based merging operation. In addition, let ObjectiveMergeable ($\mathbf{x}^i$, $\mathbf{x}^{i'}$) be used to identify whether flow i can be merged with i'; then

$$\text{ObjectiveMergeable}\left(\mathbf{x}^i, \mathbf{x}^{i'}\right) = \begin{cases} \text{false, if } \exists j \in \{1, 2, \cdots, g\} \ni \frac{\left|f_j^i - f_j^{i'}\right|}{\overline{f}_j - \underline{f}_j} > \beta_O \\ \text{true, otherwise} \end{cases} \tag{25}$$

Note that if the number of objective functions is far smaller than the number of variables in a problem, an objective-based merging test is simpler than the location-based test. However, the newly generated sub flows are subject to objective value evaluations prior to the test.

The merging operation sequentially loops through each flow i in the current flow set X to establish a flow sub set A^i that rounds in mergeable flows indexed after i. If flow i', $i < i'$, is rounded in A^i, which means flow i' is mergeable with flow i, $A^{i'}$ is set to null. On the other hand if flow i' is not merged by any preceding flow, $A^{i'}$ contains at least flow i' itself; i.e., $A^{i'} \neq \varnothing$ and $\mathbf{x}^{i'} \in A^{i'}$. To identify whether flow i can merge flow i', operation LocalMergeable(x^i,$x^{i'}$) or ObjectiveMergeable(x^i,$x^{i'}$) is applied depending on which merging mode is chosen. Suppose that flow i is not null and $A^i = \left\{\mathbf{x}^i\right\} \cup \left\{\mathbf{x}'^i_1, \mathbf{x}'^i_2, \cdots, \mathbf{x}'^i_{n'^i}\right\}$; then, there are n'^i flows that are mergeable with flow i. The merging operation simply randomly selects one flow from A^i to represent the merged flow and assigns its mass properties with the aggregated mass of all flows in A^i. Let RandomElement(A) be a random operation that returns one element of the given set A; i.e. RandomElement(A) $\in A$. Then the merged flow of a non-null flow set A^i is $\mathbf{x}'^i =$ RandomElement(A^i). In addition, the mass of the selected flow is replaced with the aggregated mass; i.e., $m'^i = \sum_{\forall i, \mathbf{x}^i \in A^i} m^i$. When all none-null mergeable flow sets are merged into single flows the flow set is further updated as

$$X \leftarrow \left\{\mathbf{x}'^i \,\middle|\, A^i \neq \varnothing \wedge \mathbf{x}'^i = \text{RandomElement}\left(A^i\right)\right\}$$

and the number of flows is as $n \leftarrow Count(A^i \neq \varnothing)$.

3.4 Water Evaporation

Evaporation operation simulates the natural behavior of water evaporating to the atmosphere. The water flow-like algorithm conducts this operation to store a certain amount of water up in the air for chances of water flow regeneration in water precipitation.

An *Evaporation Factor* α is initially set by the user, whose value is restricted by $0 \leq \alpha < 0.5$. Let the mass of the cumulated water in the air be v. In the evaporation operation, the evaporated mass of water is added to v by

$$v \leftarrow v + \alpha \sum\nolimits_{i=1}^{n} m^i$$

and the mass of each flow in X after evaporation is updated as

$$m^i \leftarrow (1 - \alpha)\, m^i; i = 1, 2, \cdots, n$$

Notice that the mass of a flow indicates the liveliness of the flow while it traverses on the ground. Once it is reduced to a minimal amount, it is regarded as a dried-out flow. The total number of flows is restricted by a user specified limit. Let the maximal number of flows allowed be $\overline{z}$; the minimal amount of mass is then $\overline{m}/\overline{z}$, where $\overline{m}$ is the user specified initial flow mass. A dried-out flow is removed from the flow set and its leftover mass is added to v; i.e.,

$$v \leftarrow v + \sum\nolimits_{\forall i, m^i \leq \overline{m}/\overline{z}} m^i$$
$$X \leftarrow X - \left\{ \mathbf{x}^i \middle| m^i \leq \overline{m}/\overline{z} \right\}$$

3.5 Precipitation

Precipitation operation simulates the natural rainfall that results in water flows covering a wide range of the territory. The water flow-like algorithm conducts this operation to generate new solution agents for exploring new solution space. When the mass of the evaporated water exceeds a user specified saturation amount the precipitation operation is conducted automatically. The limit is a fraction of the initial mass: $\rho\overline{\mathrm{m}}$; where ρ is the *Precipitation Factor* specified by the user and $0 < \rho \leq 0.5$. In other worlds, the precipitation operation is conducted when $v \geq \rho\overline{m}$.

The number of precipitation flows generated is set to the number of ground flows in X; i.e., n. However the total number of flows allowed is restricted by $\overline{z}$. On the other hand, since a minimal mass $\overline{m}/\overline{z}$ is required, at most $\lfloor v\overline{z}/\overline{m} \rfloor$ flows can be generated. Therefore, the number of precipitation flows is

$$n'' = \min \left(n,\ \ \overline{z} - n,\ \ \lfloor v\overline{z}/\overline{m} \rfloor \right) \tag{26}$$

Let $X'' = \left\{\mathbf{x}''^{1}, \mathbf{x}''^{2}, \cdots, \mathbf{x}''^{n''}\right\}$ be the set of generated precipitation flows. Evaporated mass v is then evenly distributed to generated precipitation flows. Let m''^{i} be the mass of precipitation flow $\mathbf{x}''^{i}$, then $m''^{i} = {}^{v}\big/_{n''}$. The location of each precipitation flow is directly duplicated from a randomly selected ground flow and some components are perturbed with random distances. In assigning the location of flow $\mathbf{x}''^{i}$, a ground flow i' in X is randomly selected first. Then a random distance δ_k^i for each component k, restricted by the length between lower and upper bounds, is stochastically calculated. If a forward advancement or backward retraction of distance δ_k^i from $x_k^{i'}$ exceeds the bounds, no perturbation is applied. Otherwise, either forward or backward perturbation is stochastically applied. Components of the location are set by

$$x''^{i}_{k} = \left\{\begin{array}{ll} x_k^{i'}, \text{if} \left(x_k^{i'} + \delta_k^i > \overline{x}_k \vee x_k^{i'} - \delta_k^i < \underline{x}_k\right) & \\ x_k^{i'} + \delta_k^i, \text{else if} \sim U(0,1) \geq 0.5 & ; k = 1, 2, \cdots, p \\ x_k^{i'} - \delta_k^i, \text{otherwise} & \end{array}\right\}; \quad (27)$$
$$i = 1, 2, \cdots, n''$$

Where

$$i' = \text{RandomInteger}(1, n),$$

and

$$\delta_k^i = \sim U(0,1)\left(\overline{x}_k - \underline{x}_k\right).$$

The parent flow of a precipitation flow is cloned from the selected ground flow as $\tilde{\mathbf{x}}''^{i} \leftarrow \tilde{\mathbf{x}}^{i'}$. Finally, the flow set X is augmented by precipitation flows as $X \leftarrow X \cup X''$ and number of flows is updated as $n \leftarrow n + n''$.

3.6 Water Flow Evaluation and Non-dominated Solution Set Update

The final operation performed in an iteration of water flow-like optimization algorithm is to evaluate the objectives of the solutions represented by the flows. Therefore, objective vector for each flow i in X is evaluated as

$$\mathbf{f}^i = \left[f_1\left(\mathbf{x}^i\right) \; f_2\left(\mathbf{x}^i\right) \cdots f_g\left(\mathbf{x}^i\right)\right] \equiv \left[f_j^i\right]_{1\times g}, i = 1, 2, \cdots, n$$

and the maximum and minimum objectives are updated as

$$\left.\begin{array}{l}\underline{f}_j \leftarrow \min\left(\underline{f}_j, f_j^i\right) \\ \overline{f}_j \leftarrow \max\left(\overline{f}_j, f_j^i\right)\end{array}\right\} j = 1, 2, \cdots, g$$

Moreover, the cumulated objective differences ΔF and the cumulated number of flows generated N are both updated as

$$\Delta F \leftarrow \Delta F + \sum\nolimits_{i=1}^{n} \left|F^i - \tilde{F}^i\right| \text{ and } N \leftarrow N + n$$

Notice that we have maintained the non-dominated solution set $\widehat{X}$ that will be presented to the user as solutions to the problem. Once the objectives of all flows are calculated, each flow is subject to a serial of domination tests for being added to $\widehat{X}$. To be added to $\widehat{X}$ the solution of a flow must not be dominated by any solution in both X and $\widehat{X}$. Therefore $\widehat{X}$ is augmented by new non-dominated solutions as

$$\widehat{X} \leftarrow \widehat{X} \cup \left\{\mathbf{x}^i\right\}, \text{if} \left(\underset{\forall \mathbf{x}^{i'} \in X, i \neq i'}{\wedge} \neg\text{Dominated}\left(\mathbf{x}^i, \mathbf{x}^{i'}\right)\right)$$
$$\wedge \left(\underset{\forall \mathbf{x}^{i'} \in \widehat{X}}{\wedge} \neg\text{Dominated}\left(\mathbf{x}^i, \widehat{\mathbf{x}}^{i'}\right)\right); \quad i = 1, 2, \cdots n.$$

3.7 Non-dominated Solution Set Pruning

Before presenting the final non-dominated solution set $\widehat{X}$ to the user, an extra pruning operation is required if the number of solutions s $\widehat{X}$ in exceeds the user specified maximum number $\overline{s}$. In the operation, the same procedure of removing the worst solution is recursively executed $s - \overline{s}$ times to prune $\widehat{X}$ to have exactly $\overline{s}$ non-dominated solutions left. The worst solution is the one that has the smallest *jamming distance* among the solutions. The jamming distance τ^i of a solution $\widehat{\mathbf{x}}^i$ in $\widehat{X}$ is the smallest aggregated normalized distance to other solutions on the objective space. A normalized objective distance is the objective value difference between two solutions divided by the bounding length of the objective value. Let r_j be the bounding length of objective j, then

$$r_j = \max_{i'=1,\cdots,s}\left\{\widehat{f}_j^{i'}\right\} - \min_{i'=1,\cdots,s}\left\{\widehat{f}_j^{i'}\right\} \tag{28}$$

The jamming distance of each non-dominated solution i in $\widehat{X}$ is

$$\tau^i = \min_{i'=1,\cdots,s; i \neq i'} \left\{ \sum_{j=1}^{g} \left(\frac{1}{r_j} \left| \widehat{f}_j^i - \widehat{f}_j^{i'} \right| \right) \right\} \tag{29}$$

In the repeated procedure, all r_j are updated by the objective values of all of the current solutions in $\widehat{X}$ first. Then the jamming distances of all solutions are recalculated. The solution $\widehat{\mathbf{x}}^{i^*}$ with the smallest jamming distance is then removed form $\widehat{X}$; i.e., $\widehat{X} \leftarrow \widehat{X} - \left\{ \widehat{\mathbf{x}}^{i^*} \right\}$, where $i^* = \arg \min_{i=1,\cdots,s} \tau^i$. Note that instead of executing the procedure only one time to removing $s - \overline{s}$ inferior solutions directly, $s - \overline{s}$ recursive recalculations of all r_j and τ^i are conducted to remove totally $s - \overline{s}$ solutions from the objective space. The recursive removal of the worst solution has a better ability to yield an evenly dispersed solution set.

4 Performance Index

Generational distance is a common way to evaluate the performance of non-dominant solution. In addition, this paper proposed two more performance indices are proposed to evaluate the non-dominant solution.

4.1 *Generational Distance*

Generational Distance is proposed by Veldhuize [5]. It is defined as the Euclidean distance between current computed non-dominant solution and the known global optimal solution. Smaller Generational Distance means the current obtained non-dominant solution is closer to the optimal Pareto-front solution.

4.2 *Correctness*

Correctness index is to measure that how many percentages of current obtained non-dominant solutions belong to the true optimal Pareto front. An optimizer which yields the solution with high Correctness indicates that such optimizer is credible. Correctness index is calculated as follows

$$C = \frac{\left| \widehat{X}' \right|}{\left| \widehat{X} \right|} \times 100\% = \frac{1}{\overline{s}} \cdot \left| \widehat{X}' \right| \times 100\% \tag{30}$$

Where

$$\widehat{X}' \left\{ \widehat{X^i} \middle| \widehat{X^i} \in \widehat{X} \text{ and} \forall \bigwedge_{\forall \widehat{X^i} \in \widehat{X}} \neg \text{Dominated}\left(\widehat{X^i}, \widehat{X^{i'}}\right) \right\} \tag{31}$$

4.3 Coverness

Coverness is devised to quantify how well the non-dominant solutions spread. Define the Coverness

$$\ell = \frac{u}{\left|\widehat{X}\right|} \tag{32}$$

Where u represents number of Pareto front solution covered by non-dominant solution. Define ε as user specified Radius for Pareto Neighborhood. Here Radius for Pareto Neighborhood is suggested to set as

$$\varepsilon = \frac{1}{\left|\widehat{X}\right|} \tag{33}$$

Define $\mathbb{Q} = \left\{Q^1, Q^2, \ldots Q^{\widehat{n}}\right\}$ as the sets for identifying if Pareto front solution covered by non-dominant solution. Where $\widehat{n}$ is the number of Pareto front solution. Initially $Q^{i'} = 0, i' = 1, 2, \ldots, \widehat{n}$. Each element of the set is computed as

$$Q^{i*} = \begin{cases} 1, & \text{if } \; i^* = \arg \; \min \left\{ K_j^{i'} \middle| K_j^{i'} < \varepsilon \right\}, \forall Q_{i'} = 0 \\ 0, & \text{otherwise} \end{cases} \tag{34}$$

where

$$K_j^{i'} = \sum_{j=1}^{g} \left(\frac{\left| \widehat{f}_j^{\,i'} - \widehat{f}_j^{i} \right|}{f_j^{(u)} - f_j^{(l)}} \right)^2 \tag{35}$$

and

$$u = \sum_{i'=1}^{\widehat{n}} Q^{i'} \tag{36}$$

Coverness ℓ can be obtained then. Large ℓ value means non-dominant solutions have wide spreading and able to cover most of Pareto-front solution. Notice that while using Coverness, $\widehat{n} = s$ is necessary condition.

5 Simulation Study

Simulation study in this paper is conducted in twofold. Firstly, find out the best of flow merging method in WFA. Secondly, compare non-dominant solution of WFA among other proposed methods. Recommended Parameter settings for WFA are shown as Table 1. High saturation rate setting is suggested to avoid redundant search caused by precipitation overly.

Table 2 presents the numerical result for simulation study2. Benchmark problem proposed by Zizler et al. [6] is in use for this experiment. We can obtain that OM method has better performance based on Coverness index. It indicates that OM method generates the wider range of non-dominant solution. However, two of other indices show that LM method has better overall performance.

In Table 3, generation distance shows that WFA4MC outperforms other methods in the benchmark ZDT3, ZDT4 and ZDT6. Though WFA4MC is not an overwhelming MOO method, it is still an option for solving MOO problem.

Table 1 WFA4MC parameter settings for different benchmark

	Benchmark				
Parameter	ZDT1	ZDT2	ZDT3	ZDT4	ZDT6
$\overline{m}$	50	50	50	50	50
$\overline{n}$	5	5	5	5	5
$\overline{z}$	15	15	15	15	15
ρ	0.9	0.9	0.9	0.9	0.9
α	0.1	0.1	0.1	0.1	0.1

Table 2 Performance LM and OM methods

Average	Generational distance		Coverness		Correctness		Obj. recalling number
Benchmark	LM	OM	LM	OM	LM	OM	
ZDT1	**0.000508**	0.00072	**65.5**	64.7	**0.973**	0.971333	30, 000
ZDT2	**0.000427**	0.00049	**98.3**	96.2	0.9545	**0.965333**	30, 000
ZDT3	**0.000501**	0.0005	40.4	**44.5**	0.8531	**0.861724**	30, 000
ZDT4	**0.000438**	0.00048	**98.4**	97	**0.979**	0.965423	250, 000
ZDT6	**0.000991**	0.00107	**0.45**	0.37	0.9036	**0.918946**	30, 000

Table 3 Benchmark problems on different methods

Benchmark	WFA4MC (LM)	WFA4MC (OM)	AMOPSO	NSGAII	MOEPSO
ZDT1	0.0004	0.0004	0.0215	0.0243	**0.0002**
ZDT2	9.71E-05	9.80E-05	0.0083	0.0214	**9.43E-05**
ZDT3	**0.0002**	**0.0002**	0.0058	0.0126	0.0005
ZDT4	**0.0002**	**0.0002**	0.0224	0.0217	0.0185
ZDT6	**0.0009**	0.001	0.0167	0.0195	0.0177

6 Conclusion

In this paper, a multi-objective continuous problem solver WFA4MC based on WFA is proposed. WFA mimics the phenomenon of water flow in the nature, consisting of flow splitting, flow merging and precipitation.

In addition, other than generational distance, this paper proposed two novice criteria for non-dominant solution evaluation such as correctness and Coverness index. Firstly, correctness calculates the percentage that current non-dominant solutions are not dominated from the true non-dominant solutions. Secondly, Coverness quantifies how well the current non-dominant covers the true Pareto front. Three total indices are applied to evaluate two of the flow merging mechanism, OM and LM. Simulation result shows that though LM can gain smaller generational distance, OM has higher correctness.

Comparing with AMOPSO, NSGAII and MOEPSO, Simulation study based on generational distance index shows that our proposed method outperforms other methods in several benchmarks.

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Part III
Lean Manufacturing

Current Research Situation and Development Overview of Product Innovation Based on Lean Six Sigma

Xin Guo, Wu Zhao, and Chen Wang

Abstract This review has carried out selective analysis of innovation theories and practice achievements based on 6σ approach and summarized the basic theories on product innovation by means of 6σ approach, innovative practice through combination of 6σ with entity enterprises, 6σ and TRIZ as well as 6σ innovation model and application. The paper has proposed three further research directions, i.e. continual and thorough application of 6σ management to improve product quality, further strengthening of the research of 6σ in process innovation, and deep expansion of application of 6σ management by domestic enterprises to guide innovative practice.

Keywords Product innovation • Quality improvement • Six Sigma (6σ) management

1 Introduction

W.A. Shewhart created statistical quality management approach in 1924 and further expanded it to Total Quality Management in the quality management area. With the structural changes of customers' requirements for products, the quality management has also evolved from TQC to the era of "6σ Quality Management" [1]. The concept of 6σ management was initially put forward by Bill Smith in 1980s. As a key optimization method for modern enterprises to realize significant improvement of organization competitiveness, "based on fact decision-making", 6σ management takes "zero defect" of product quality as its mission to substantially improve enterprises' product quality and strengthen the quantitative index of production and management flows. With abundant technical tools as its support, 6σ management

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makes the "once for all" production objective run through every process of practice. It views customer demand as its highest concern. 6σ level not only represents the yield of product quality above 99.9997 % but also guarantees the daily defect ratio of product quality characteristics reaches 3.4 ppm.

As a high-standard quality management style, 6σ management's operation and research processes accompany the generation of innovation. Even if the input is increased after production flow and product design are improved to 4.8σ level, it may act in a diametrically opposite way [2]. We need starting from DMAIC, DFSS, etc. which integrate product innovation and flow innovation to strengthen Voice of The Customer (VOC), Concept Resolve (CR), and Design Optimize (DO). Also, we shall utilize tools like AHP-QFD, FBS Mapping, d-FMEA and CPK to improve the product quality from the origin and drive enterprises' development by relying on innovation.

Product innovation based on 6σ approach refers to the product innovation theory and practice centering on quality during the full life cycle. This paper takes design, process, and manufacturing processes as the key analysis targets and the research focuses on the key word of "Six Sigma". The related monographs and papers already published in previous years are integrated and analyzed based on CNKI platform and research achievements related to innovation are selected. 765 papers have already been published in relevant periodicals among which 120 are published in core periodicals and 2 are published in EI; also, there are 11 doctoral dissertations and 395 master's dissertations. The research started from 2000. Both quantity and quality have been increased year by year over the past decade. The research features various layers and involves multiple areas like industry guidance, basic research, engineering technology and policy research.

2 Analysis on Achievements of Innovation Research Under the Background of 6σ Management

6σ management, aiming at improving product quality and reliability, shortening research and development duration, and lowering development cost, is another emerging direction recently opened up by the academic circles when studying the knowledge on research innovation theory. After summarizing and sorting relevant literatures, this paper abstracts the core viewpoints and describes the research achievements of 6σ management in the innovation area from the following four aspects:

2.1 Research Achievements of Basic Theory of 6σ Management in Innovation

Fang Yuan [3] thinks an innovative concept based on lean design, as the ore service, can eliminate all wastes exposed in the process. It creates bigger value for customers involved in each link of the flow, satisfies the maximum degrees of the customers within the minimum duration, and explores from four aspects, namely, quality culture, implementation flow framework, tool, and program development simulation; M.M. Parast [4] considers that enterprises shall strengthen the combination of lean 6σ management and reduction of variance in a dynamic environment due to relatively significant changes and complete their quality management and process management based on relevant theories; Zhao Yuzhong [5] utilizes the method of data screening to build a structural equation model capable of reflecting the performance influence relationship between product management elements and management system; Ge Liang [6] has worked out an intersection point between 6σ management and excellence performance management through comparison and research of 6σ management and Criteria for performance excellence (a national quality award of China). Long Bin [7] has verified the strong enterprise practicability and standardization of innovation flow possessed by 6σ management theory by utilizing two improving items, i.e. continuous variable and discrete variable. Such researches have realized the "all-in-one" theoretical innovation of 6σ management in areas like product design, process design, production and total integrated management as well as highlighted a further expensive research space in aspects like lean 6σ (Lean Six Sigma) innovation model design, enterprise production flow design and product innovation research and development.

2.2 Research Achievements of Innovation Practice Through Combination of 6σ Management with Entity Enterprises

R. Bañuelas and J. Antony [8] have carried out practice testing of a British transnational corporation and a European laundry equipment producing enterprise. Based on the combination of 6σ quality management and DFSS, they have verified the applicability of multi-objective decision scheme and analytical hierarchy process scheme; the research object of K. Xu, C. Sikdar and M. Gardner [9] is General Electric Company (GE) of the United States. The research indicates that a simplified and digital modern enterprise 6σ quality system enables GE to promote innovation faster than ever in the past; Sun Yulin [10] has utilized the case of SEG to describe the necessity of establishing an improving scheme according to the requirements of 6σ level to tackle internal friction which is a persistent ailment of state-owned enterprises so as to further complete a scientific enterprise management system, and a cultural construction and operation mechanism; He Zhen [11] has proposed that the essence of management innovation of an enterprise lies in the optimization and continual improvement of management flow and insistence on the improvement of core competitiveness of the enterprise in the process to reach the objective of substantial improvement of profitability by using the BPI cases of Baosteel Group, Aviation Industry Corporation of China and Dell; Liao Huicheng [12] applies SWOT analysis results to put forward multiple theories and practice modes a service-oriented enterprise may draw lessons from concerning flow innovation according to the current logistics management situations of port enterprises in Shenzhen; Zhang Chuanping [13] focuses on the driving product cases of S Company and adopts DIVALC model to design several innovation management methods like VIP management flow and service timing system to effectively promote the sustainable development of enterprise management. These researches attach importance to the combination of different cases of entity enterprises to further verify and expand the practice meaning of 6σ quality management in production activities so as to provide powerful application support for multiple academic researches. It is thus clear that the further practice innovation from macro to micro and from enterprise to product is bound to become another development direction of such researches.

2.3 Research Achievements Combining 6σ Management and TRIZ Theory

Dai Queqiao [14] thinks a new model integrating TRIZ theory and 6σ management helps enterprises realize the quality objective of 6σ faster with the support of TRIZ innovation theory. In the era of heated research on TRIZ, the win-win objective can be realized by substantially improving the innovation capacity of the enterprises and working along both lines of "Innovation" and "Quality"; Shao Yunfei [15] has built a system integrating TRIZ and DMAIC, the core model of IFSS and a system integrating TRIZ and DMADV, the core model of DFSS based on the integration theory of TRIZ and 6σ, thus providing a highly practical innovation model which utilizes DFSS to solve actual problems; X.J. Zhao [16] makes sure that customers' demands can be successfully handled, the quality problems of the products are corrected to improve the innovation speed, and DMAIC and TRIZ are combined to enable the products to own an interest-supported life cycle through integration of TRIZ; Wang Lixia [17] has linked Lean Six Sigma (LSS) and Continuous Process Improvement (CPI) in a ground-breaking manner and combined CPI concept, LSS method and model system to propose a new model of LSS in the entity enterprise management flow system based on TRIZ theory; aiming to solve the problems existing in the defining stage of DMAIC model by DFSS, Chen Zishun [18] combines TRIZ and problem analysis and decision-making theories to construct a new framework of defining issues of DMAIC model and prove its effectiveness in practice. When the research of TRIZ enters the deepwater region, the crossing research with 6σ management is imperative. The implementation of high standard in every detail of innovation is the route these researches must take.

2.4 Research Achievements of Applying 6σ Management to Generate Innovation Models to Solve Actual Problems

There are many methods to solve actual problems under 6σ management background. Solutions differ greatly when confronted with different problems:

Gui Yunmiao [19] designs an optimum scheme for shipment and freight transport flow when confronted with the issue of airfreight revenue. Gui summarizes the links existing between yield and process capability index by utilizing "Rule + Case" knowledge model and airfreight model based on customers' demands; Zhao Yuzhong [5] utilizes linear structure relation method and partial least squares method to obtain a structural equation model capable of reflecting the performance influence relationship between product management elements and management system and work out its acting relation and degree; Su Wentao [20] utilizes the case of CTG to build a customer satisfaction management system model according to the Human Resources Outsourcing (HRO) services of this enterprise, by combining ISO and 6σ management theory, and based on Customer Relationship Lifecycle Management (CLM) and Total Customer Satisfaction (TCS). Innovation emphasizes on method. A full set of product design and manufacturing models established based on 6σ may lead the enterprise to take the new innovative development path represented by advancement, normalization and standardization.

3 Development Direction of 6σ Management Innovation in Research and Application

As for manufacturing enterprises, amidst the waves of global economic integration in the twenty-first century, it is the most critical development direction to keep their core competitiveness through re-innovation of products, technologies and services in this smokeless war of market and profit. They shall utilize 6σ management in a reasonable manner, start from production process or product design, and master core technologies relying on innovation to lead the enterprises to smoothly break "5σ" wall. It is easy to discover from the discussion of this paper that the research development of 6σ management is very quick and involves a great range, thus being favored by enterprises and researchers. However, it is regarded in this paper that the following three directions are be used as the breakthroughs to further study 6σ management based on the existing researches.

3.1 Continual and Profound Research on Improvement of Product Quality Under the Background of 6σ Management

Many enterprises are usually incapable of redesigning and reproducing brand-new and competitive products according to their objectives due to lack of manpower and material resources or insufficiency of innovation funds during the application of 6σ quality management. They often have to continue to use the existing products to meet customers' requirements and approach 6σ quality level through reconstruction of functions and appearance or local improvement and innovation of manufacturing flow, marketing method, etc.. So, the research on improvement of product quality under the background of 6σ management appears very crucial. The research in this direction can be carried out from the following three angles: (a) Establish a model of DFSS for redesign of existing products (services); (b) Establish a product quality improvement model by integrating QDF, CAPP, DOE and 6σ quality management; (c) Establish a reasonable mode to effectively manage the product quality by combining the improvement model of DMAIC and combine it with the strategic objective of the enterprise to improve its quality and organization service level.

3.2 Further Strengthening the Research on 6σ Management in Process Innovation

As the soul of the progress of a nation, innovation has already become a main driving power for the social development of China in recent years. In the stage featuring quick development of manufacturing industry and increasingly powerful production level, that how to change "Made in China" to "Designed in China" has always been a key for manufacturing enterprises to make breakthroughs. The core to solve this problem is how to own new generation of products belonging to the enterprise itself and compare them with domestic and foreign advanced achievements. The author thinks the process design of product production is of special significance besides the improvement of the design levels of the products including functions, appearances and software and hardware. Currently, the research on innovative thinking methods and innovative design based on 6σ quality management has already become a research focus of design methodology. However, there are still no theoretic researches on Computer Aided Process Planning and process innovation design method. The researches on this area are reflected in three aspects: (a) How to utilize the knowledge in process design area and combine 6σ quality management to carry out innovative design; (b) How to give full play to the advantages of design for 6σ, break the mindsets and output innovative concepts with process designer as the subject; (c) How to apply TRIZ theory, 6σ quality management theory and creative formwork into the process design.

3.3 Deep Expansion of Research on Problems Generated from Innovation Practice Led by Domestic Enterprises Through Application of 6σ Management

6σ quality management is often related to the product design and manufacturing of enterprises. Since the practical meaning of innovative design concept is greater than its theoretic meaning, it is the most essential content of 6σ quality management as how to utilize concept and innovative design model to link theory with practice.

The currently existing research achievements clearly indicate the launch of domestic empirical research is still lagged behind although the concept and relevant theories of 6σ quality management have been proposed very early. Most researches at present remain at the level of theoretical pioneering and innovation. Besides, no enough researches have been conducted on the problems encountered in actual production practice and the problem solving models. Although some specific cases are now available as materials, they are often not typical enough. The researchers hardly summarize problem solving models of strong practical significance from common problems to break the bottlenecks encountered in production practice.

4 Summary

6σ quality management is a set of systematic innovative improving method system which takes the realization of customer satisfaction as its ultimate objective. The improvement of product quality is carried out by multiple approaches and tools with designers as the subject and innovation model as the supplement to realize defect-free output so as to further improve the quality and service level. Through shortening of production cycle, reduction of cost and enhancement of enterprise competitiveness, the research has reached the deepwater region of innovation practice at present. When facing existing achievements, the researchers shall further explore new areas, expand the innovation visions of design and production personnel, and utilize innovative design and 6σ quality management by combining the objectives and requirements of 6σ quality management, which will inevitably become a vigorous guarantee for enterprises to break “5σ wall”.

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Value Stream Mapping Application in Service-Oriented Manufacturing Company A

Yan Zhao, Rui Miao, Min Ge, Jie-yun Zhang, and Xiao-xu Deng

Abstract This paper mainly introduces value stream mapping (VSM) methodology of lean production, which focuses on the whole process and according to the analysis can eliminate no-value adding parts. In addition, it studies the application of VSM during implementing lean production, which proves the effectiveness and efficiency of the tool in lean production.

Keywords Lean production • Value stream mapping

1 Introduction

There is an important "Learning to See" tool, Value Stream Mapping (VSM) in lean production system. We use VSM to state current status and future status when implementing lean production. The fact proves that once the enterprise focus its work on the flow and value stream mapping, it can bring excellent results for the enterprise [1, 2]. VSM is a key tool when lean production implement [3]. In the process of implementing lean, we often get confused by the chaotic background of enterprise and do not know how to conduct improvement activities. In this situation, it's necessary to use an effective tool or method which can helps us to find out what is unwanted and then eliminates it directly. VSM is the tool what we need [4]. This paper studies the application of VSM in lean production implementation that can provide a reference for the enterprise when applying implementation of lean production.

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2 Concept of VSM

2.1 Concept of VSM

Value stream refers to a product through its whole activities of the production process, including value added activities and non-value added activities [4]. Value Stream Mapping(VSM) is an important tool that helps company to analyze the whole value stream. And we can use it to draw the intricate value stream to a visual current VSM, which can reveal the problems in the production and as a result the non-value adding parts can be eliminated by lean techniques or methods. Taking a value stream perspective means the study must focus on the whole process rather than individual processes. The optimizing must extend to the whole efficiency rather than just one part.

2.2 The Origin and Application of VSM

In the 1980s, Toyota's chief engineer, Taiichi Ohno and sensei Shigeo Shingo pioneered an innovation method of obtaining a competitive advantage by removal production waste; their starting point is to improve production efficiency instead of improving product quality. The reason why they conducted this concept is that they believed the improvement of production efficiency will contribute to the lean production, which can expose deep waste problem in the system and quality issues; can provide a field-based and effective way in implementation of lean production and methods, to help the enterprise in implementation process of the lean manufacturing to better seek out the source of the waste and eliminate it, and then improve the competitiveness of the enterprise The enormous advantages of implementing lean production in the enterprise have been recognized by the world through the great successful implementation in Toyota Motor Corporation in the 1980s, Dell in the 1990s and other companies. More and more enterprises have introduced lean production. However, in the course of pushing lean production many companies only seek and eliminate the large-scale waste without analyzing the whole value stream of the product carefully. Of course the KAIZEN activities may have improved a little of the product's value stream, make it flow more smoothly, but the inventory problem caused by the remained parts would be far more than little, in the end the final result maybe reverse to lower costs. Thus, there will be a big limitation to the persistence of the improve effect, it cannot be achieved in the 'whole process to reduce waste', and will prevent the implementation of lean production from proceeding. Using VSM technology can not only get rid of waste, but also eliminate the root of waste, and banned them from stage a comeback. VSM technology has been accepted and adopted by many companies around the world, and really got a good effect.

3 Application of VSM

3.1 *Starting Point for the Application of VSM*

We should have some prerequisites or plenty of advance preparations to use VSM in the Lean production implement process: First, selecting a product family. Drawing all product flows on one map is too complicated, so it is necessary to analyze the product family and then choose the most appropriate one. We can use a matrix like Fig. 1 to find out the product portfolio with same or similar processes. What your customers care about is their specific products, rather than all the products in your shop floor. So you should not map everything without filtering unrepresentative sorts.

Second, appointing one to personally lead the mapping effort, the person who we called 'Value Stream Manager' should with the capability of being familiar with all the value stream of product family and taking the responsibility for pushing improvement and has enough leadership ability. To ensure his rights to conduct improvement activities, this 'Value Stream Manager' must report to the top manager directly.

It should begin from the 'door-to-door' level, so we can clarify the scope of the implementing of VSM. In lean manufacturing, information flow should be treated as much important as material flow. Material and information flow are just like two sides of one coin. You must take both of them into mapping consideration. Thus we can use mapping tool to assist in the implementation of lean production.

	FAMILY	CODE	Process steps & equipment												
			SMT (B)	SMT (T)	M/A	WS	Rtr	B/C	2nd MA	Pre. FIT	M/W	FA	ICT (G)	ICT (HP)	BST
Products	Group A	1M001D	√	√	√	√		√		√		√	√		
		1L001A	√	√	√	√		√		√		√	√		
		1L002B	√	√	√	√		√		√		√	√		
		1L003A	√	√	√	√		√		√		√	√		
		1L004A	√	√	√	√		√				√	√		
		1L005A	√	√		√		√		√		√	√		
		1M002C	√	√		√				√		√	√		
		1M003D	√	√		√				√		√	√		
	Group B	2W001A	√	√				√	√	√				√	
		2W002A	√	√				√	√	√		√		√	
		2W003A	√	√				√	√	√		√		√	
		2W004A		√					√			√		√	
		2W005A		√						√		√		√	

Fig. 1 Product matrix

3.2 Implementation Steps of VSM

The specific implementation of VSM can be summarized as the following steps [5, 6]:

1. Draw the current-state map.
2. Find out improvement opportunities on the base of developing and discussing current-state map.
3. Draw the future-state map.
4. Set up Value Stream Plan, and conduct improvement projects to realize the future state-map.
5. Launch a new round of VSM event.

Below will present the application methods of VSM combined with the actual situation of company A:

Step 1: According to above product matrix and product forecast, Group A accounted for 35 % in all products forecast, which is the largest demand in product family. Here we select Group A as the standard product to start VSM analysis, and collect its information to draw current state VSM.

We should pay attention to the following mapping tips:

1. Collecting current-state information while walking the actual material and information flows yourself.
2. Make a sense of whole value stream first, then go back and gather information at each process.
3. Begin at the shipping end and work upstream, and then set the Takt according to the customer demand.
4. Record by yourself with a stopwatch and do not rely on any report forms or information that you did not personally get.
5. Map the whole value stream by a specific person. Several people are allowed to help him to do some preparation work
6. Insist on hand drawing. The rough sketch should begin in the meantime you start to analyze current state, and then revise them step by step.

After gathering information of product Group A, we can organized it into Current State VSM like Fig. 2

Step 2: Discuss in groups, analyze and mark the improvable point based on Current State VSM. The marked flag in Current State VSM is Burst (Fig. 3).

Current state VSM can help us intuitively to find waste in process. All these waste points are what we called Kaizen chances, on which we can push lean production by means of reducing or eliminating wastes in improving activities [4]. It requires everyone to work in team and develop brain storm to find out the waste in process, and then fix the improve point according to the actual condition.

VSM application processes are consisting of four modules; they are customer demand, raw materials logistics, information flow and supportive improvement.

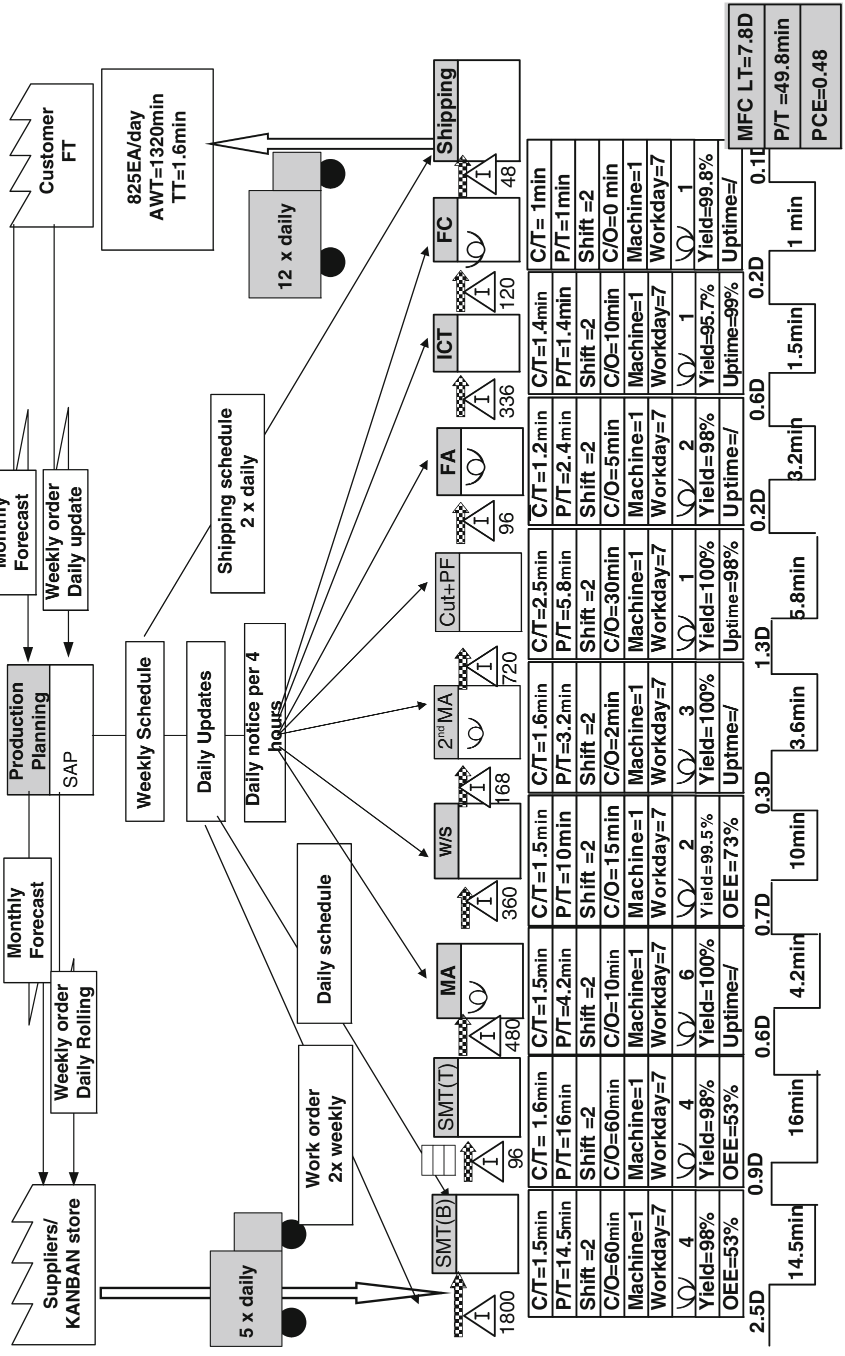

Fig. 2 Current state VSM

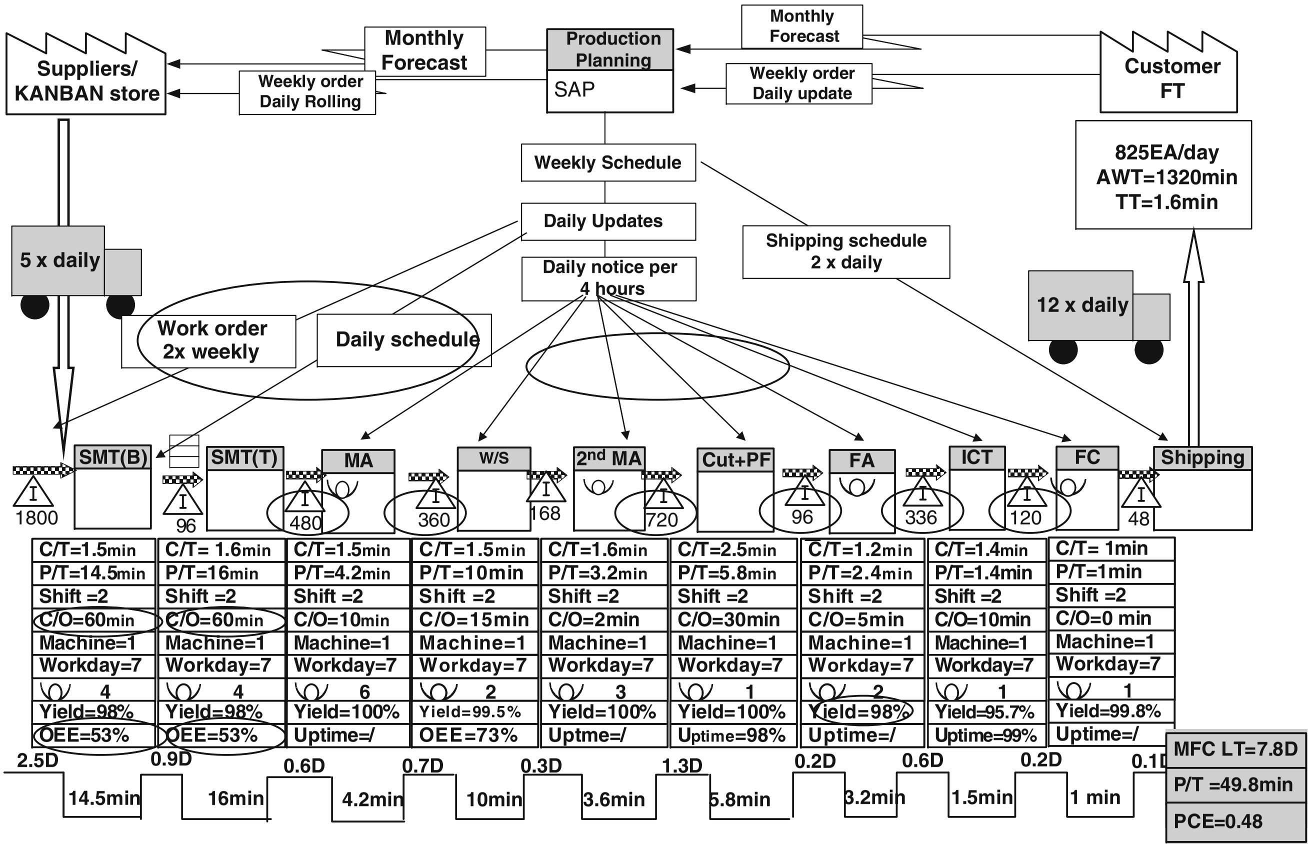

Fig. 3 Burst in current state VSM

These four modules act as the guiding line in the VSM. It's the most effective way to find improving point along with this guiding line. Answer following questions one by one, then you can find the point need to be improved. Based on your answers to these questions, mark you future-state ideas directly on your current-state map [1, 7].

1. What is Takt time?
2. Build a finished goods supermarket from which customer pulls, or just shopping directly?
3. Where is suitable to set a continuous flow processing?
4. Where is suitable to build a supermarket pull systems to control the production of upstream processes?
5. On which station in the production chain is appropriate to schedule production?
6. How to level the production mix in one pacemaker process?
7. How to calculate the volume for production launch and pick up in the pacemaker process?
8. Which process and facilities are required to get
9. improvement so as to realize the flow of value stream as future-state design specifies?

Step 3: According to the discussion and the Burst in current state VSM, you can draw a future-state map like Fig. 4.

The future state VSM is a blueprint of our goal of implementing Lean improvement. We need practical improvement programs to achieve it, otherwise, it will not have any significance.

Step 4: Design action plan for the improvement according the burst in current state VSM and the future state VSM. The improvement plan should include improvement purpose, target, action owner, time point and other information [5]. Then Implement the project according the action plan, the action owner should responsible for the project results and the VSM manager should responsible for achieving the future state VSM. The improvement plan such as Table 1.

Regular reviewing of the subprojects in the improvement plan to confirm the progress of the improving actions, to see that there is difficult or not in the implementing process, to provide support to the action owner to reach the target smoothly. Here omit the detail implementation process of the subprojects.

Compare the current state VSM with the future state VSM, from the statistical data we can find exciting results. Greatly reduced the WIP, and vastly improved the productive efficiency. The MFC lead time from 7.8 days reduced to 2.7 days. The contrast table of current state and future state in Company A as Table 2.

Step 5: After achieving the target blueprint of the future state VSM, we finished one VSM cycle. Then should set about the next VSM activity cycle, and the starting line of the improvement activity is the status after the last VSM improvement cycle.

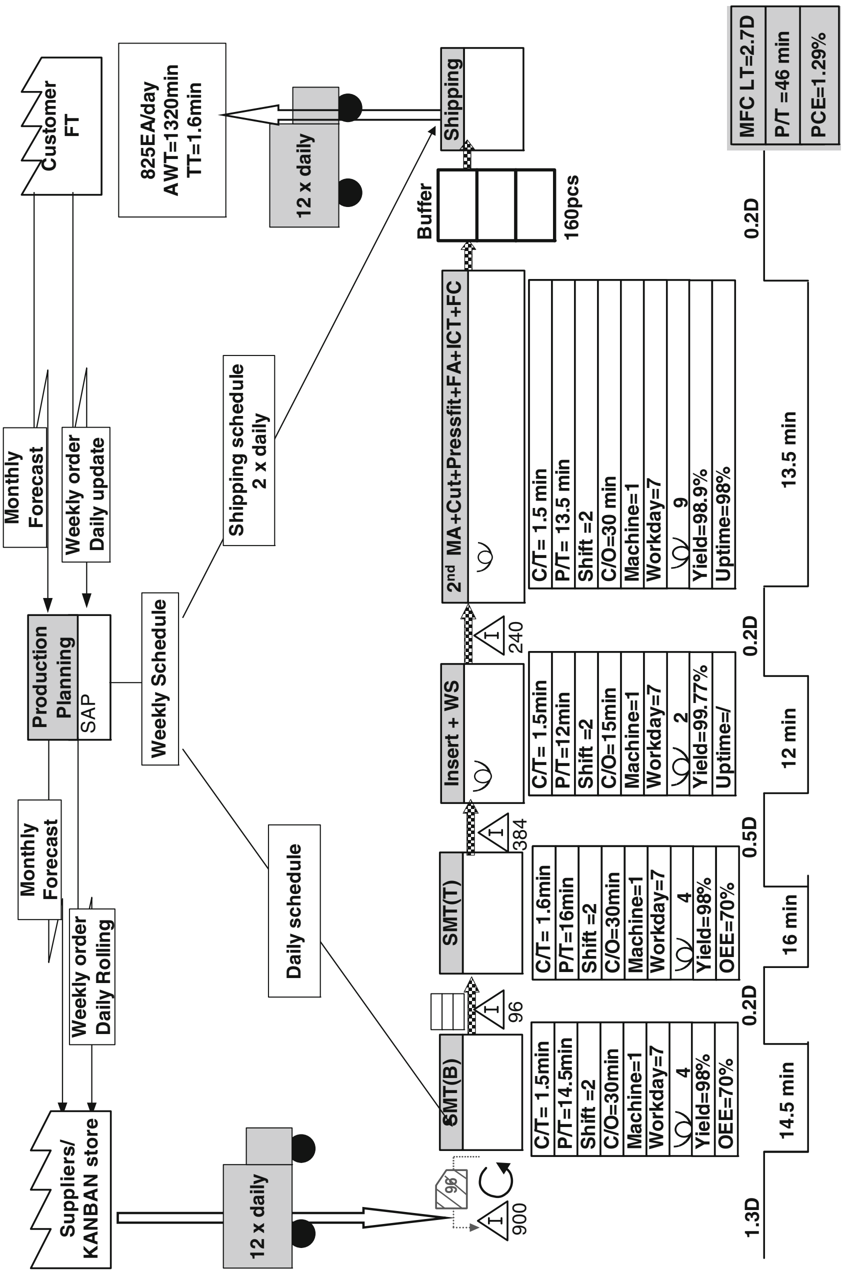

Fig. 4 Future state VSM

Table 1 Improvement plan

Item	Issue	Action	Target	Owner
1	MA and WS have repetitive motion, routing is complex, more WIP	To redesign production line, combine MA and WS into Inser + WS stream line	LT reduction by 50 %	Sheng
2	Assembly process is scattered, routing is complex, more WIP and LT is long	To redesign production line to realize continues flow	WIP reduction by 50 %	Liu/Zhao/Li
3	SMT OEE is low	To increase SMT OEE	>70 %	Zhang/Liu
4	ICT first pass rate is low	To increase first pass rate	>98 %	Song/Qu
5	WS first pass rate is low	To increase first pass rate	2,700 PPM	Sean
6	Assembly failure rate is high	To reduce assembly failure rate is high	<1 %	Liu/Li

Table 2 Future state vs current state

Item	Metrics	Current	Future	Improvement rate
1	MFC LT	7.8 D	2.69 D	65.40 %
2	WIP	4224EA	1780EA	58.00 %
3	OEE	53 %	72 %	19 %

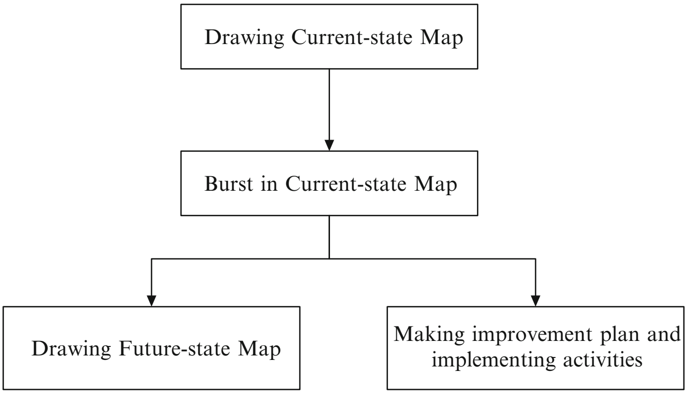

Fig. 5 Steps of VSM

3.3 Summary of the Application of VSM

In short, the application of VSM can be stated with below chart, Fig. 5 [8]. Below chart indicates the direction of VSM application.

VSM application in A company is very effective, and assist lean production team to find all kinds of waste. It also plays a key role for lean projects development.

4 Conclusion

Regardless of our products are tangible goods, services, or both, we have to be responsible for clients, so we must take this cycle improvement as the daily management of the center will continue to implement the lean production. VSM is effective way and method which is based on on-site implementation of lean production [1, 8–10]. This article profiling by Company A value stream mapping applications, the reference value stream analysis for the company's willingness to implement lean manufacturing, careful analysis of their own value stream, and seek for their own company's value stream mapping method. This paper focuses on the application of value stream mapping process, not expatiating on how to draw value stream mapping.

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The Relationship of Team Efficacy, Team Learning Behavior and Team Performance

Ming-fei Li and Ting Li

Abstract Teamwork plays more and more important roles in organization performance nowadays. Many research articles prove that team efficacy leads to team performance. This paper aims to explore whether team learning can mediate team efficacy and team performance.

Keywords Teamwork • Team efficacy • Team learning behavior • Team performance

1 Introduction

The growth in teamwork highlights the importance of understanding what helps teams to function effectively. Many studies have focused on how team composition, processes, and the organizational context influence team performance. During the 1990s, team efficacy (the perceived teams' collective capability of working together to achieve tasks) [1] started to be used to predict performance. Although team efficacy has been recognized as important for team performance, few studies have examined mechanisms that link team efficacy and team performance, Only Edmonson in her 1999 study revealed that team efficacy did not have significant effects on team learning when psychological safety was controlled [2]. At the same time, many research results also revealed that team learning can increase team performance [3–6]. Our research question is whether team efficacy can increase team learning since team performance can be influenced by both team efficacy and team learning.

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2 Literature Review and Conceptual Framework

2.1 Team Efficacy and Team Performance

Team efficacy is based on an aggregated concept of self-efficacy from the individual level to the team level [7]. Bandura has argued that efficacy is as important at the team level as at the individual level, and there is considerable evidence for the effects of efficacy at the group or team level. Team efficacy is a team's self-confidence (or belief) in its capability to successfully accomplish specific teamwork [8]. Teams with a strong sense of team efficacy set more challenging goals, persist in the face of difficulty, and are ultimately more likely to succeed than teams who do not share this belief [1]. We contend, however, in agreement with Bandura, that efficacy is a team-level variable to the extent that individual team members agree that their team can perform successfully on a given task [9]. Team efficacy originates in individual team members, and through team processes of social interaction and mutual task experience the members' self-efficacy jointly converges into a team-level factor [10]. Principally, team efficacy signals what a team thinks it can do, influences what team members choose to do, how much effort they invest in aiming to reach the team's objectives, and their persistence when initial team efforts fail to obtain good performance. The level of team efficacy is often related to how much effort the team makes and it has been found to be a determinant of team performance. High team efficacy can lead to successful teamwork performance in a variety of achievement-related situations. Team efficacy, defined as a team's shared belief that they can execute a task successfully, is an important antecedent to team performance. A strong link exists between team efficacy and performance. Several researchers have proved that strong team efficacy helps improve team performance [2, 11–18].

2.2 Team Learning Behavior and Team Performance

Educational philosopher John Dewey described learning as an iterative process of designing, carrying out, reflecting upon, and modifying actions, in contrast to what he saw as the human tendency to rely excessively on habitual or automatic behavior [19]. Edmonson conceptualized learning at the team level of analysis as an ongoing process of reflection and action, characterized by asking questions, seeking feedback, experimenting, reflecting on results, and discussing errors or unexpected outcomes of actions [2]. Discussing differences of opinion openly rather than privately or outside the team is considered learning behavior, as it is through them that learning is enabled at the team level. Argote, Gruenfeld, and Naquin looked at team learning as both processes and outcomes of team interaction activities [20]. Since team members can interact with one another, knowledge and skill gathered by one team member can be transferred to the other team members, which can affect the efficiency and performance of the team's collective learning process [21, 22].

Team researchers have been interested in finding the process variables that affect team performance. As today many teams are confronted with change or uncertainty, teams must engage in learning activities to understand their environment and their customers for effective self-management and team process improvement. Learning may help a team to adapt to changing circumstances, continually refine processes and practices, and discover new and better ways of achieving team objectives, which will finally result in a better team performance [23]. Several authors proved that team learning behavior is positively related to team performance [2–6].

2.3 Team Efficacy and Team Learning Behavior

However, there was not much literature about the relationship between team efficacy and team learning behavior.

Edmonson's study proved that team efficacy enables learning behavior when team members had psychological safety [2]. She did not explain clearly if there is some overlap between team efficacy and team psychological safety since she put these two variables in the same position to check their influence on team learning behavior.

Pescosolido [24] study on MBA students showed that team efficacy had significant effects on the willingness to join the team, motivation to learn and self-develop in the team [24].

The existing limited literature did not explicitly explore the relationship of team efficacy and team learning. Our initial belief is that team efficacy should have effects on team learning. However, there might exist some other interactive factors between the two.

2.4 Team Efficacy, Team Learning and Team Performance

However, unlike the relatively straightforward relationships obtained at the individual level, the team-level relationships between team efficacy beliefs and team performance that have been observed are modest, complex, and apparently moderated by other factors in the workplace. Many researchers have been studied the factors which effect the relationship between team efficacy and team performance, such as team-set goal difficulty, psychological safety, task uncertainty, collectivism and gender diversity [2, 25–28]. Theoretically, it seems likely that team efficacy is distinct from the individual beliefs team members hold about themselves or their team, because team efficacy arises through team interaction and the process of collective cognition. That is, team efficacy forms as team members collectively acquire, store, manipulate, and exchange information about each other and about

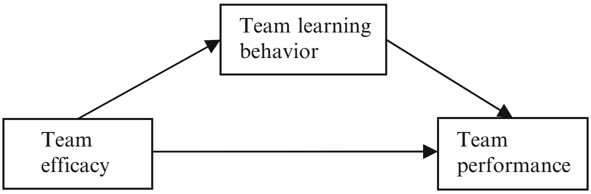

Fig. 1 A conceptual framework of team efficacy, learning behavior and team performance

their task, context, process, and prior performance. Through processes of interaction, this information is combined, weighted, and integrated to form team efficacy. These same collective processes do not occur during self-efficacy formation or when members form individual beliefs about their team.

Many factors may complicate this process by prohibiting or encouraging information exchange or by making salient certain categories of information. Our research interest is how team efficacy associated with team performance? Whether learning behavior mediates them?

One possibility is that efficacy fosters team members' confidence, which promotes learning behavior and helps accomplish desired team goals. Team efficacy, which is members' confidence in the team's ability to do the specific job, is likely to contribute to asking questions, seeking feedback, experimenting, reflecting on results, and discussing errors or unexpected outcomes of actions, these activities are likely to promote effective performance, learning behavior-which include all of these activities-is also likely to facilitate performance. That is to say, team efficacy is characterizing the team's potential to perform, team efficacy does not play a direct role in the team performance; rather, it facilitates the team's taking appropriate actions to accomplish its work. Thus, learning behavior should mediate the effects of team efficacy on performance outcomes.

The framework is as following in Fig. 1. Team efficacy is positively associated with team learning behavior. Team learning behavior is positively associated with team performance. And Team learning behavior mediates between team efficacy and team performance.

3 Implication and Future Research

The team level relationship between team efficacy and team performance is more complex than the one in individual level. The study finding will help understand the mechanism of the above relationship. At the same time the finding will help managers to realize the importance of increasing team's belief on their capability to get the task done.

In this paper, we just explain the relationship among team efficacy, team learning behavior and team performance theoretically. Although it is helpful to understand the relation among these factors by scholars and managers, we need further empirical studies to verify and understand the mechanism in ongoing teams in real organizations.

With the development of virtual team and cross-functional team, we need to focus on the particular team in the specific occupational situation, make further research on the variables related with team efficacy and the development trend.

Most of the previous studies focus on one of the specific stages, and ignore the dynamic change process. Team efficacy and team learning behavior is developing along with the team development. Issues of how team efficacy develops over time and how learning behavior might alter undesirable structural factors warrant careful consideration and future research.

Finally, in the different cultural contexts of the East and the West, team efficacy may show different relationships with other variables. We should explore the issues of team efficacy in the Chinese context, rather than quote the research results directly.

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ISM-Based Analysis of Influencing Factors and Countermeasures of Construction Safety

Zhui Dong, Heng-ying Li, and Hai-qing Yin

Abstract Through the systematic analysis of causing factors of the construction safety accidents, the relationship among 12 causing factors was confirmed. By using ISM theory, the hierarchical ISM model was constructed, which assort all causing factors of construction safety accidents into three hierarchies. The direct reasons are construction workers' safety awareness and safety equipment and facilities. The indirect reasons are machinery and equipment maintenance and improvement, labor intensity, inputs of security cost, and construction schedule. The root reasons are construction safety laws and regulations, and quality of managements. According to the search results, root reasons are vital influencing factors, which are in-depth and fundamental. Besides, construction safety accidents analysis proved the applicability of the ISM model.

Keywords Construction safety • Interpretative structural modeling • Influencing factors

1 Introduction

In 2011, it is reported that there were a total of 589 accidents and 738 deaths from housing municipal engineering safety production. The number of accidents was decreased by 38 and the death toll by 34 people, which respectively falls year-on-year by 6.06 % and 4.40 % [1]. The current situation of production safety is still severe. There still exist a relative large number of accidents and deaths; tremendous accidents happen now and then; major accidents have not completely contained and the number of accidents and deaths rose in certain areas.

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Take the year of 2011 as an example, several causes can attribute to housing municipal engineering production safety accidents. Among them, there are 314 falling accidents (53.31 %); 86 collapse accidents (14.60 %); 71 struck by equipment and machineries accidents (12.05 %); 49 lifting injury accidents (8.32 %); 30 electric shock accidents (5.09 %); 20 equipment damage accidents (3.40 %); 19 other accidents (3.23 %).

Of all types of accidents, 471 cases are caused by falling, collapse, struck by equipment and machineries, which accounts for 81 % of the total, and statistically the above three types of accidents has reached to 79 % in the 2010 national housing municipal engineering production safety accidents. This paper intends to analysis above accidents based on the interpretative structural modeling (ISM) to identify key factors and propose appropriate countermeasures.

2 Basic Principles and Working Procedures of ISM

The interpretative structural modeling (ISM) is developed by J.N. Warfield between the year 1971–1973 as a systematical analysis approach for the analysis of complex systems [2]. ISM has a very wide range of applications, from the energy, resources and other international issues to domestic range of issues such as regional development, traffic accidents, as well as the problems within the scope of enterprises and individuals. Almost all these areas can apply this method [3]. It can be applied at all stages of the systems engineering, especially effective unified views.

This approach adopts the principle of the incidence matrix in graph theory to analyze the overall structure of complex systems, which are then decomposed into several subsystems (elements). Through incidence matrix, the direct relations of inter-linkages and restrictions between various elements of the system can be described. Then by further calculation, the indirect relationship between the various elements will be found and thus figures could be adopted to show both direct and indirect relations. According to such an approach, the fundamental influencing elements of the system would be found out. For the working procedure of ISM, please refer to the references [4].

3 ISM Model of Construction Safety Influencing Factors

3.1 Analysis of Influencing Factors and Their Interactions

Through access to a large number of relevant literatures, 12 factors that may affect construction safety could be initially identified. They are as follows: construction safety laws and regulations (S1), managements' safety awareness (S2), construction workers' safety awareness (S3), machinery and equipment maintenance and

Table 1 System factors' direct relation

Elements serial number (i)	Influencing factors (Si)	Elements serial number (i)	Influencing factors (Si)
0	1–12	7	6
1	No	8	No
2	1,6	9	1,8,10,12
3	1,2,7,8	10	No
4	1,2,6,7,11,12	11	1,4,6,8,9,10,12
5	1,2,4,6,7,9,11,12	12	8,10,11
6	No		

improvement (S4), safety equipment and facilities (S5), quality of managements (S6), quality of construction workers (S7), complexity of the project (S8), labor intensity (S9), work environment (S10), inputs of security cost (S11), construction schedule (S12). Their own strength and the extent of inter-action of these factors determine the construction safety accident rate (S0). These 12 factors, through a questionnaire, are distributed to relevant experts to evaluate the interaction between these elements. Then after summarizing the evaluation results and considering the views of all parties, the relationship between the above factors is obtained. Table 1 presents the interaction between these factors.

3.2 Establishment of the Adjacency Matrix

Based on the above relation tables, the adjacency matrix can be listed. Adjacency matrix is the square matrix which expresses the basic binary relations between elements of the system or direct relations. Figure 1 shows the adjacency matrix.

3.3 Establishment of the Reachable Matrix

According to adjacency matrix, the reachable matrix M. is calculated by the Matlab software. Figure 2 shows the reachable matrix M.

3.4 Dividing Elements by Hierarchy and Establishing ISM

Reachable matrix elements can be divided into reachable set R (Si) and first set of A (Si). Reachable set is a collection of elements of the system that Si can reach in reach-able matrix. Antecedent set is a collection of elements of the system that can

Fig. 1 The adjacency matrix

$$\begin{pmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\
1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 0 \\
1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 \\
1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 \\
1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\
1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1
\end{pmatrix}$$

Fig. 2 The reachable matrix M

$$M=\begin{pmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\
1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\
1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\
1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 1 \\
1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 1 \\
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1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\
1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 \\
1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\
1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1
\end{pmatrix}$$

reach Si in the reachable matrix. By calculating the R (Si) ∩ A (Si) = R (Si), the most superior unit is gained, then remove them temporarily. Similarly, the sub-unit could be calculated. By successively dividing the elements, the elements are at last divided into multi-rank hierarchical structure. Through calculation, the sys-tem is

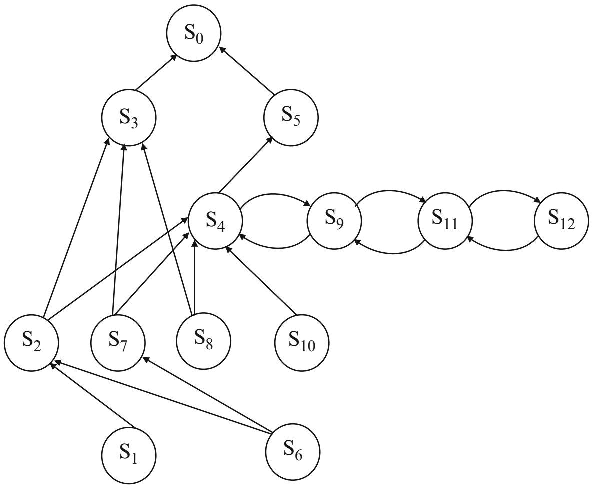

Fig. 3 The analytic structure of the construction safety influencing factors

divided into five layers as follows: I: 0; II: 3,5; III: 4,9,11,12; IV: 2,7,8,10; V: 1,6. Original reachable matrix is then divided by hierarchy. Figure 3 shows the analytic structure.

4 Conclusion

Based on the above analysis, it can be concluded as following:

The direct influencing factors of construction safety accidents are construction workers' safety awareness (S3), safety equipment and facilities (S5). To reduce construction safety accidents, the security awareness of construction workers should be enhanced first. At present, the majority of the construction workers in China are migrant workers, and a lot of them are temporary workers [5]. Their sense of security is very weak, and self-defense capability is poor. So many construction workers lack knowledge and skills of in construction safety operations, and treat the safety training prior to the approaching work as a form. Therefore, we should focus on reinforcing the safety education training of construction personnel, enhancing their safety awareness and improving their safety skills. Only by the systematic training of construction personnel, can effectively improving the safety of construction workers' operation skills and self-protection awareness be achieved.

Construction enterprises' security education and training can fall into three stages [6]. The first stage is to see the exhibition and video so that every personnel could acquire a general concept before entering the construction site, such as knowing the division and setting of the site functional areas, the location of the clinic, emergency gathering place, and emergency treatment after a security incident. The second stage can carry out relevant safety training to construction personnel, mainly allow them to clear the project safety requirements, handling method after a security incident, the pre-arranged planning of an emergency event, and safety requirements of machinery and equipment and personal safety protective equipment. The third stage of security education and training is safety technical clarification. For each assignment and establish workers' education ledger. Construction workers must be experience a period of safety and operating skills training, and tested to obtain the certificate before the construction work. Construction workers who do not follow the operation specifications, rules and regulations should be educated, if they refuse to mend one's ways after repeated education, they may be dismissed.

Construction enterprises should also continue to increase investment in safety equipment, personal safety protective equipment, security facilities and facilities maintenance funds to ensure the effective operation of safety equipment and facilities. Then effective security measures should combined with the specific circumstances of construction. Besides, adequate security of critical security facilities is also needed in construction projects.

The fundamental influencing factors of construction safety accident are construction safety laws and regulations (S1), quality of managements (S6). To reduce the accident rate, the development and implementation of construction safety laws and regulations must be strengthened. For example, American's Common Law, Workmen's Compensation Law and Occupational Safety & Health Administration have made stipulations to determine the responsibility of the construction site safety. The safety management of the project and the economic interests of the contractor are closely linked by forcibly buying Worker's Compensation insurance and the premium rate regulation [7]. Germany has strictly implemented Labor Protection law. At the same time, the Industry Association has played a very important role in many aspects such as work-related injury insurance and research education, accreditation of security professionals, prevention and treatment of occupational diseases, and security incident handling [8]. Japan has carried out Industrial Accident Prevention Organization Law and Industrial Safety and Health Law to effectively prevent architectural production accidents [9]. Morning meeting system is implemented in the project department of all construction enterprises [10]. At the same time to raise the cultural level of the management staff, thus contributing to the improvement of the quality. Through communication and study, the management level of management is improved and the occurrence of security incidents is reduced.

Machinery and equipment maintenance and improvement (S4), labor intensity (S9), inputs of security cost (S11), construction schedule (S12). The factors mentioned above have a strong mutual influence between each other. Thus it should also be given sufficient attention in safety management of construction projects.

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Identify Unsafe Behavior Proneness Coal Miner: A Fuzzy Analogy Preferred Ratio Method

Zheng-quan Xu and Hua-qing Wang

Abstract Coal miners who are prone to accident tend to be more likely to violate coal mining regulations than the average ones do, so the safety supervisors need to pay more attention to making them under control in the process of coal mining. However, it is difficult to for the safety supervisor to accurately find who has unsafe behavior propensity in practice. To resolve the above questions, fuzzy analogy preferred ratio method is used, in this paper, to identify coal miners who have a tendency to take unsafe actions in the coal mining activity. The method involves two key steps: find similarity factors of different miners; and rank miner by the similarity. Results reached in this paper show that the method is an effective tool to find coal miners prone to taking unsafe actions, which can also facilitate the supervisor to find coal miners who are accident-proneness, and make them under stricter control.

Keywords Coal mine • Fuzzy analogy preferred ratio method (FAPR method) • Unsafe actions • Unsafe behavior proneness

1 Introduction

Analysis of accident statistics shows that unsafe actions are leading causes that induce coal mining accidents [1–3]. For coal mining enterprises in China, there are a large number of rule-violating actions occurring in the process of coal mining, most of which are unsafe actions of coal miners. Although safety supervisors strive to prevent these unsafe actions by enacting strict coal mining morns and regulations, yet they are not always effective. Heinrich's accident analysis report of 'root of

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accident' indicates that causes inducing injuries accidents need to repeat for certain times to make an accident take place [4]. That means that the possibility of one unsafe action incurring accident is very low, it is unlikely to incur an accident immediately, so unsafe action may be embraced by the miners and not be prevented by the safety supervisors immediately. However, unsafe actions can make the coal miners get more returns than they use safe actions, so that they will attract more other miners to learn and imitate, and also make the unsafe actions more valuable as the number of the coal miners taking the unsafe actions increases. By this the unsafe actions will be reinforced, and repeated. When they accumulate and reach a certain number of times, the possibility of the inducing accidents will increase heavily.

Although many coal mining regulations are enacted to prevent unsafe actions of the coal miners, yet their effectiveness is limited. There are two reasons for this. One is that there not exists clear boundary line between safe actions and unsafe actions. The other is that occurring of unsafe actions seems to be random, and lacks regularity, which makes it difficult for the safety supervisors to find the miners prone to taking unsafe actions.

Accident-proneness theory suggests that some people might be more likely to suffer accidents, such as coal mining injuries, than other people. If these people can be paid more attention to, possibility of accidents taking place will be lowered. This paper uses the FAPR method to identify and categorize the coal miners who are prone to taking unsafe actions. The study shows the effectiveness of the method in finding the coal miners that perform unsafe-behavior-proneness, therefore, the supervisors can use, in the safety management practice, the method to identify the coal miners who are prone to adopting unsafe behaviors, and they will be received more control and intervention from the supervisor. By this the efficiency of safety management in coal mining activity can be improved.

2 Accident-Proneness Theory and Its Implication

Greenwood and Yule are the forerunner of studying accident-proneness [5]. Farmer and Chambers firstly conceptualize the accident-proneness [6]. Since then theory of accident-proneness does not receive too much attention either from the academic researcher or from practitioners [7]. Between 1955 and 1975 in the world of accidents theory the researchers find that accidents incurred by the accident-proneness individuals just represent a very small percentage of total accidents, so that they think design of the work environment and of the safety systems in place is more important than identification of individuals having accident propensity [8]. More recently, however, some researchers use a meta-analysis to examine the distribution of accidents in the general population and find that some individuals are more prone to accident than others [9, 10]. Theory of accident-proneness indicates that some individuals having more accidents relate to their personality that develops during their youths. Thus the personality feature of the individuals makes them more easily suffer accidents, namely some people prone to accidents. For example, some children who live in unsafe environments never have an accident, while others who live in safe environments suffer repeatedly from accidents [11]. Moreover, accident proneness also relates to gender. Generally speaking, males are more likely to suffer accidents than females [12].

Evidences for the existence of accident-proneness have been confirmed by the vast relative literature in academic world and cases from safety management practice. Chiara Pavan examines the existence of the predisposition to burn incidents by an empirical study which shows that impulsiveness may have contributed to bringing about the "burn" event [13]. Andrea et al. note that individuals working under high pressure are more likely to have an accident [14]. In China, some researchers and practitioners identify 21 types of people who are accident prone. Evidences, whether from the academic world or from the practice, show that accident-proneness does exist, namely, some individuals are more prone to adopting unsafe actions, and having an accident in the workplace than others. Thus accident-proneness theory is also used, in this paper, as the theoretical basis of identifying coal miners who have a tendency to have more accidents.

3 Methodology

The fuzzy analogy preferred ratio method (FAPR method) is used, in this article, to identify the coal miners who are accident prone. Using this method, all miners who need to be identified are compared in pairs. It comprises two steps [15]:

(1) Construct a FAPR matrix. Let $M = \{X_1, X_2, \cdots, X_n\}$ be a finite set of miners needed to be identified, and let X_k be the benchmark miner who is accident prone. Arbitrarily take two elements, X_i, X_j, in M, and compare them with X_k, we can get a fuzzy relation, $\underset{\sim}{R} = \left(r_{ij}\right), r_{ij} \in [0, 1]$. if $r_{ij} \in [0, 0.5)$, this denotes that X_j is better than X_i; if $r_{ij} \in [0.5, 1)$, this denotes that X_i is better than X_j; if $r_{ij} = 0$, this means that X_j is absolutely better than X_i; if $r_{ij} = 0.5$, this means that we can't judge the priority between X_j and X_i; if $r_{ij} = 1$, this suggests that X_i is absolutely better than X_j. For the convenience of computing, Hamming distance is employed to compute r_{ij}. Let

$$r_{ij} = \frac{\rho_{kj}}{\rho_{kj} + \rho_{ki}}$$

Where, $\rho_{ki} = |X_k - X_i|$, $\rho_{kj} = |X_k - X_j|$.

(2) Rank the accident-proneness degree of the coal miners according to the cut matrix. When the set of the sample of the coal miners needed to be identified contains large number of elements, for the convenience of comparing the elements, M_λ is calculated according to the value of r_{ij}. That is

$$M_\lambda = \left(r'_{ij}\right), \text{where } r'_{ij} = \begin{cases} 1, r_{ij} \geq \lambda \\ 0, r_{ij} \leq \lambda \end{cases}, \quad \lambda \in [0, 1]$$

When the values of λ decrease to λ_1, according to the above formula, the elements of the i_1 row in M_{λ_1} all become zero, and for the given sample set, X_{i_1} is most similar to X_k. Remove the coal miner in the sample set who is most similar to the benchmark miner, a new FAPR matrix is constructed. Repeat above steps until the similarity of the miners to the benchmark miner is ranked.

4 Data Collection and Analysis

4.1 Coal Miners Needed to Be Identified

Most of the unsafe actions in the coal mining activity, in China, are caused by the coal miners. Their entire underground workings are very complicated and volatile, and full of risk factors, so that whatever unsafe actions of them are likely to incur accident. In this article, for the purposes of the identification, we just choose the coal miners working teams or groups as the sample. For the sake of this work to be representative, a morning shift working team of the coal mine located in Xuzhou, Jiangsu province, is selected as sample, whose members' tasks are to operate the mechanical and electrical equipment. There are ten members in the team. By the above method, we will rank the degree of the accident proneness of coal miners in the sample. According to the rank, the safety managers can choose the miners of none accident proneness as the members of the working team. By this the hidden danger caused by unsafe actions of the miners might be restrained.

4.2 Selection of Similar Factors

Selecting similar factors is involved in four steps.

Step one. We use ways of the questionnaires, expert interview and field observation to search for the factors that impact the accident proneness of the coal miners. In practice, a large number of factors can be gained, so nominal group technique is used to select the factors that can play more influence on the accident proneness. To rank the importance of the factors, the experts will vote for them. The factors that get most of the votes from experts are chosen as the similar factor. According to the results of voting, emotion, attention, behavior habit, and ability are chosen as the similar factors. Generally speaking, the miner who is accident prone can't get very high score in his emotion, attention, behavior habit, and ability.

Step two. Give the benchmark miner who is accident proneness. According to the data collected in (1), the benchmark miner can be determined. Then we will

Table 1 Values of similar factors of each miner

	Miners needed to be identified								
Similar factors	X_k	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
Emotion (D1)	4.4	7.2	7.8	8.0	3.8	7.6	7.8	7.8	6.2
Attention (D2)	3.8	8.2	7.8	8.0	4.2	8.0	7.8	8.0	6.2
Habit (D3)	4.6	7.8	7.6	7.6	4.4	7.2	7.4	7.0	6.0
Ability (D4)	4.6	7.4	7.2	7.6	5.0	7.4	7.8	8.0	5.8

calculate the score that the miner can get in his emotion, attention, behavior habit, and ability. The score of the other miner can be gotten through the same way.

Step three. Determine the score range of the similar factors. For the convenience of data processing, the scores of emotion(range from bad to good), attention(range from low to high), behavior habit(range from bad to good), and ability(range from weak to strong) are divided into ten levels, namely from 1 through 10. The data of the similar factors are gotten from questionnaires.

Step four. Collect Data. The evaluators consist of one standing mine manager, one work area director, one safety officer, two miners who never have an accident (because of these two miner acting as the evaluators, we just need to identify the remained 8 miners). Their task is to determine the scores of the coal miners in the respective similar factors. Because of evaluators have been working together with the miners needed to be evaluated for a long time, they can make an objective evaluation on the miners.

4.3 Data Processing

According to the process of data collecting, we can get the data that show in the Table 1.

Further, we can compute the similar matrix of each similar factor by the Hamming distance.

$$M_{D1} = \begin{bmatrix} 0.50 & 0.55 & 0.56 & 0.18 & 0.53 & 0.55 & 0.55 & 0.39 \\ 0.45 & 0.50 & 0.51 & 0.15 & 0.48 & 0.50 & 0.50 & 0.35 \\ 0.44 & 0.49 & 0.50 & 0.14 & 0.47 & 0.49 & 0.49 & 0.33 \\ 0.82 & 0.85 & 0.86 & 0.50 & 0.84 & 0.85 & 0.85 & 0.75 \\ 0.47 & 0.52 & 0.53 & 0.16 & 0.50 & 0.52 & 0.52 & 0.36 \\ 0.45 & 0.50 & 0.51 & 0.15 & 0.48 & 0.50 & 0.50 & 0.35 \\ 0.45 & 0.50 & 0.51 & 0.15 & 0.48 & 0.50 & 0.50 & 0.35 \\ 0.61 & 0.65 & 0.67 & 0.25 & 0.64 & 0.65 & 0.65 & 0.50 \end{bmatrix}$$

1. The similar matrix M_{D1} of Emotion (D1) factor

$$M_{D2} = \begin{bmatrix} 0.50 & 0.48 & 0.49 & 0.08 & 0.49 & 0.48 & 0.49 & 0.35 \\ 0.52 & 0.50 & 0.51 & 0.09 & 0.51 & 0.50 & 0.51 & 0.38 \\ 0.51 & 0.49 & 0.50 & 0.09 & 0.50 & 0.49 & 0.50 & 0.36 \\ 0.92 & 0.91 & 0.91 & 0.50 & 0.91 & 0.91 & 0.91 & 0.86 \\ 0.51 & 0.49 & 0.50 & 0.09 & 0.50 & 0.49 & 0.50 & 0.36 \\ 0.52 & 0.50 & 0.51 & 0.09 & 0.51 & 0.50 & 0.51 & 0.38 \\ 0.51 & 0.49 & 0.50 & 0.09 & 0.50 & 0.49 & 0.50 & 0.36 \\ 0.65 & 0.63 & 0.64 & 0.14 & 0.64 & 0.63 & 0.64 & 0.50 \end{bmatrix}$$

2. The similar matrix M_{D2} of Emotion (D2) factor

$$M_{D3} = \begin{bmatrix} 0.50 & 0.48 & 0.48 & 0.06 & 0.45 & 0.47 & 0.43 & 0.30 \\ 0.52 & 0.50 & 0.50 & 0.06 & 0.46 & 0.48 & 0.44 & 0.32 \\ 0.52 & 0.50 & 0.50 & 0.06 & 0.46 & 0.48 & 0.44 & 0.32 \\ 0.94 & 0.94 & 0.94 & 0.50 & 0.93 & 0.93 & 0.92 & 0.88 \\ 0.55 & 0.54 & 0.54 & 0.07 & 0.50 & 0.52 & 0.48 & 0.35 \\ 0.53 & 0.52 & 0.52 & 0.07 & 0.48 & 0.50 & 0.46 & 0.33 \\ 0.57 & 0.56 & 0.56 & 0.08 & 0.52 & 0.54 & 0.50 & 0.37 \\ 0.70 & 0.68 & 0.68 & 0.13 & 0.65 & 0.67 & 0.63 & 0.50 \end{bmatrix}$$

3. The similar matrix M_{D3} of Emotion (D3) factor

$$M_{D4} = \begin{bmatrix} 0.50 & 0.48 & 0.52 & 0.13 & 0.50 & 0.53 & 0.55 & 0.30 \\ 0.52 & 0.50 & 0.54 & 0.13 & 0.52 & 0.55 & 0.57 & 0.32 \\ 0.48 & 0.46 & 0.50 & 0.12 & 0.48 & 0.52 & 0.53 & 0.29 \\ 0.88 & 0.87 & 0.88 & 0.50 & 0.88 & 0.89 & 0.89 & 0.75 \\ 0.50 & 0.48 & 0.52 & 0.13 & 0.50 & 0.53 & 0.55 & 0.30 \\ 0.47 & 0.45 & 0.48 & 0.11 & 0.47 & 0.50 & 0.52 & 0.27 \\ 0.45 & 0.43 & 0.47 & 0.11 & 0.45 & 0.48 & 0.50 & 0.26 \\ 0.70 & 0.68 & 0.71 & 0.25 & 0.70 & 0.73 & 0.74 & 0.50 \end{bmatrix}$$

4. The similar matrix M_{D4} of Emotion (D4) factor

According to the above four similar matrix respectively, namely, M_{D1}, M_{D2}, M_{D3}, M_{D4}, and for the different levels of λ, the similarity of the coal miners can be obtained, see the Table 2.

The Table 2 shows that the rank of similarity of the coal miners, in comparison to the benchmark miners, is $X_4 \rightarrow X_8 \rightarrow X_5 \rightarrow X_2 \rightarrow X_6$ or $X_7 \rightarrow X_1 \rightarrow X_3$. By this, the miner, X_4, is most similar to the benchmark miners, so he, in all of the miners, is the most likely to have an accident. Besides, the miner, X_3, is least similar to the benchmark miners.

Table 2 Rank of the similarity of the coal miners

	Factors				
Miners	D_1	D_2	D_3	D_4	Total
X_1	3	6	7	4	20
X_2	5	3	6	3	17
X_3	6	5	6	5	22
X_4	1	1	1	1	4
X_5	4	4	4	4	16
X_6	5	3	5	6	19
X_7	5	4	3	7	19
X_8	2	2	2	2	8

5 Conclusions

In this work we introduce the FAPR method to identify the accident-proneness miners, and several results can be gained from the method. First, the effectiveness of the method can be showed from the results in the Tables 1 and 2. Second, the method combines the subjective judgment with objective evaluation to measure the similarity, so that the results gained in this work are reliable.

The findings indicate that individuals who are more likely to have an accident at work are more similar to the benchmark miners. This also is confirmed by our subsequent interview to the miners. Therefore, if the miners who are accident prone can be identified and be paid more attention to controlling over their behavior, then the possibility of the incurring accidents will be reduced.

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Part IV
Logistics Engineering and Supply Chain Management

Multi-echelon Inventory Control Model and Algorithm in Coal Supply Chain

Kai Kang, Jing Zhang, Lu Ji, and Cui-juan Shang

Abstract The inventory control in coal supply chain is an important guarantee for reducing the total inventory costs and running sustainably. This article firstly introduced the multi-echelon inventory control theory into coal supply chain, and established a mathematical model, which was the distributed two echelon inventory control model in coal supply chain, taking total inventory costs minimum in a certain customer service level as the goal. Then genetic algorithm was presented to solve the optimal reorder point, order batches and allocating batches of the regional distribution centers and storage and distribution bases. Finally, concrete examples were calculated separately by the distributed two echelon inventory control strategy in supply chain based on information coordinating center and traditional coal inventory control strategy. The comparing results indicated the effectiveness of the distributed two echelon inventory model and algorithm in coal supply chain based on cost optimization.

Keywords Coal supply chain • Genetic algorithm • Multi-echelon inventory control • Total inventory costs

1 Introduction

As an indispensable basic energy, coal resource plays a crucial role in ensuring national economic to be stable. In China, geographically, the coal production and marketing system shows a distributed multi-echelon reverse distribution. A complete coal supply process needs highways, railways, waterways and other transportations to realize [1, 2]. The coal production and transportation system determines the

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equilibrium between coal supply and demand. However, due to the influence by uncertain factors such as dynamic, seasonality, burst and constraints of the transport conditions, there is a high degree of uncertainty in the coal supply chain, consisting of the uncertainties in supplement, demands and supply chain connection. Therefore each node enterprise in coal supply chain tends to set a higher inventory level to prevent the uncertainty of the order cycle and to reduce the risks and losses of coal supply. However, high coal inventory costs directly lead to the rising of coal price in the circulation process, which has a significant effect on the operating cost of a single enterprise and the whole performance of the coal supply chain.

Many of studies at home and abroad on the coal inventory control have focused on the internal inventory control in a single enterprise, and considered that each firm often adjusted their relationship by a large amount of buffer stocks [3–7]. Because of lacking the systemic and cooperative awareness, it's hard to share information between enterprises. So there is a serious bullwhip effect in coal production and transportation system [8]. The multi-echelon inventory control in supply chain is formed on the basis of the single-echelon inventory control, which globally optimized the supply chain resources. Multi-echelon inventory control theory has achieved fruitful results in the study of the manufacturing supply chain [9, 10]. Therefore, this research bases on multi-echelon inventory control theory in supply chain, regarding the coal supply chain as a distributed multi-echelon inventory system which is constituted by the node enterprises in many different industries. The reasonable inventory scheduling is conducted by the order control in coal supply and demand, which can effectively reduce or even eliminate the redundant transport of coal and reduce the total inventory costs of the coal supply chain. Ultimately this model would inhibit the rising prices in the coal circulation process to achieve a balanced supply of coal in China.

2 Modelling

The coal supply chain is a complex system, including upstream coal production enterprises, midstream logistics firms and downstream coal consumption enterprises [11, 12]. In recent years, China has strengthened the construction of the regional distribution centers and storage and distribution bases. Using the geographic advantages and equipment advantages of coal storage and distribution bases, the coal from different regions is transported to storage and distribution bases, then the regional distribution centers complete the short distance distribution for the users in this area, which achieves the coal integrated storage, mixed processing, transportation and distribution [13, 14]. Based on the needs of the end users, the coal begins in the coal production enterprises, then is transported to the regional distribution centers and storage and distribution bases, and ultimately reaches the coal customers in different areas through different modes of transport such as road transport, rail transport, and water transport [15]. Considering coal production enterprises, storage and distribution bases, regional distribution centers and the users as the inventory nodes, a distributed multi-echelon network structure is formed. This paper regards the regional distribution centers and storage and distribution bases as a distributed two echelon inventory system. These two echelon nodes do not generate demand and the demand derived from the final users. The coal producers and final users are the system external supply source and the demand source separately, which are not in the scope of multi-echelon inventory control in the coal supply chain.

Based on the analysis of the impact factors on the coal supply chain inventory costs, the multi-echelon inventory control conceptual model in coal supply chain presented in this paper considers four inventory costs including ordering cost, holding cost, transportation cost and stock-out cost. In order to facilitate the model solution, make the model not too complex and have a practical value at the same time, this paper gives the following hypothesis:

H1: As an external supply source, the coal production enterprises don't consider the constraint of its supply capacity, that is to say the coal production enterprises can meet the demand of the storage and distribution base unlimitedly.
H2: The final users' demand in each regional distribution center is independent and identically distributed, and the demand of unit time obeys the normal distribution, neglecting of the impact of prices on the demand of coal.
H3: During the decision-making period, the fixed ordering cost, unit holding cost, unit transportation cost and unit stock-out cost in the coal supply chain are approximately constant.
H4: The coal distribution and processing costs at the storage and distribution bases attribute to the cost of storage, not separately computed.
H5: The order batch and replenishment batch must be above the minimum transport unit and can not be larger than the maximum transport bulk.
H6: The lead time in coal ordering is set a given value, consisting of the coal preparation time at the coal supply enterprises and the shipping time.
H7: The storage capacity for each node is limited, and the largest inventory can not exceed the capacity.
H8: This inventory cost model allows out of stock and the customer service level (the fill rate) is a given value.

2.1 Mathematical Model 1: Total Inventory Cost in Regional Distribution Center System

When the total inventory downs to the total order point in the regional distribution center, the information coordinating center will determine to order the coal. The ordering cost is fixed and generated only once when ordering, however, storage cost, transportation cost and cost of stock-out losses are various in different regional distribution centers. Therefore the ordering cost of a single regional distribution center requires be calculated separately and then aggregated to the total ordering costs of the regional distribution centers system. So the function of total ordering costs in the regional distribution center system at time t is given by (1) below:

$$TTR_1 = OCR_1 + \sum_{n=1}^{N} \begin{bmatrix} HCR_n \times t \times \sum_{D_n \le I_n + Q_n} (I_n + Q_n - D_n) \times P_n(D_n) \\ +TCR_{nm} \times Q_n + \\ PC_n \times \sum_{D_n > I_n + Q_n} (D_n - I_n - Q_n) \times P_n(D_n) \end{bmatrix}$$

$$= OCR_1 + \sum_{n=1}^{N} \begin{bmatrix} HCR_n \times t \times \int_0^{I_n+Q_n} (I_n + Q_n - x) \times \frac{1}{\sqrt{2\pi t}\sigma_n} e^{-\frac{(x - t\mu_n)^2}{2t\sigma_n^2}} dx \\ +TCR_{nm} \times Q_n + \int_{I_n+Q_n}^{+\infty} (x - I_n - Q_n) \times \frac{1}{\sqrt{2\pi t}\sigma_n} e^{-\frac{(x - t\mu_n)^2}{2t\sigma_n^2}} dx \end{bmatrix} \tag{1}$$

The constraints when religion distribution center orders are:

$$\begin{cases} I_n + Q_n \le V_n \\ Q_n \le G\max_{nm} \\ Q_n \ge G\min_{nm} \end{cases} \tag{2}$$

Constraints (2) indicate: The sum of the existing inventory and order batches in regional distribution center n can not exceed its storage capacity. The order batches of n can not exceed the maximum transport capacity. The order batches of n can not be less than the minimum transport unit.

The information coordinating center sends out allocating instruction to the regional distribution centers when the inventory levels of the regional distribution centers down to the reorder point and the total inventory levels of all regional distribution centers do not down to reorder point. Liking the ordering process, the allocating cost is fixed and generated only once when allocating among regional distribution centers. The transport cost among regional distribution centers is undertook by the enterprise who allocates in. when regional distribution center j allocates to regional distribution center n, n is the firm that allocating in and the transport cost is included in the cost of n. The function of total allocating cost in the regional distribution center system at time t is given by (3, 4, and 5) below:

$$TTR_2 = OCR_2 + \sum_{n=1}^{N} \begin{bmatrix} HCR_n \times t \times \sum_{D_n \le I_n + Q_n} (I_n + Q_n - D_n) \times P_n(D_n) \\ + \sum_{\substack{j=1 \\ j \ne n}}^{N} \delta(Q_{nj}) \times TCR_{nj} \times Q_{nj} \\ + PC_n \times \sum_{D_n > I_n + Q_n} (D_n - I_n - Q_n) \times P_n(D_n) \end{bmatrix} \tag{3}$$

$$\delta(x) = \begin{cases} 1 & x > 0 \\ 0 & x \leq 0 \end{cases} \tag{4}$$

$$Q_n = \sum_{\substack{j=1 \\ j \neq n}}^{N} Q_{nj} \tag{5}$$

The constraints when religion distribution center allocates is:

$$\begin{cases} 0 < I_n + Q_n \leq V_n, \textit{When allocating in} \\ -(I_n - RR_n) < Q_n < 0, \textit{When allocating out} \\ |Q_{nj}| \leq G\max_{nj} \\ |Q_{nj}| \geq G\min_{nj} \end{cases} \tag{6}$$

Constraints (6) show: The sum of the existing inventory and allocating batches in regional distribution center n can not exceed its storage capacity. Excluding the batches that allocated out, the existing inventory of n can not be less than the reorder point. The allocating batches between regional distribution center n and regional distribution center j can not exceed the maximum transport capacity. The allocating batches between n and j can not be less than the minimum transport unit.

The function of total inventory costs in the regional distribution center system at time t is referred in (7):

$$TTR = \delta\left(\sum_{n=1}^{N} RR_n - \sum_{n=1}^{N} I_n\right) \times TTR_1 + \delta\left(\sum_{n=1}^{N} I_n - \sum_{n=1}^{N} RR_n\right) \times TTR_2 \tag{7}$$

The function of reorder point in regional distribution center n is referred in (8):

$$RR_n = LT_n \times \mu_n + SS_n = LT_n \times \mu_n + z_n \times \sqrt{LT_n} \times \sigma_n \tag{8}$$

The function of total reorder point in the regional distribution center system is referred in (9):

$$RR_0 = \left(\frac{1}{N}\sum_{n=1}^{N} LT_n\right) \times \sum_{n=1}^{N} \mu_n + z_0 \times \sqrt{\frac{1}{N}\sum_{n=1}^{N} LT_n} \times \sqrt{\sum_{n=1}^{N} \sigma_n^2} \tag{9}$$

2.2 Mathematical Model 2: Total Inventory Costs in the Storage and Distribution Base System

When information coordinating center representing these storage and distribution bases who need to reorder orders the coal from the production enterprises, the ordering cost is fixed and is generated only once. However, the storage cost, transportation cost, cost of stock-out losses are various in different storage and distribution bases. Therefore, the ordering cost of a single storage and distribution base requires be calculated separately and then aggregated to the total ordering costs of the storage and distribution bases system. So the total ordering costs function in this system at time t is given by (10):

$$
\begin{aligned}
TTD_1 &= OCD_1 + \sum_{m=1}^{M} \Bigg[HCD_m \times t \times \sum_{D_m \le I_m + Q_m} (I_m + Q_m - D_m) \\
&\qquad \times P_m(D_m) + TCD_{mi} \times Q_m \Bigg] \\
&= OCD_1 + \sum_{m=1}^{M} \Bigg[HCD_m \times t \times \int_0^{I_m+Q_m} (I_m + Q_m - sx) \\
&\qquad \times \frac{1}{\sqrt{2\pi t}\sigma_m} e^{-\frac{(x - t\mu_m)^2}{2t\sigma_m^2}} dx + TCD_{mi} \times Q_m \Bigg]
\end{aligned} \tag{10}
$$

The constraints when storage and distribution base orders are:

$$
\begin{cases}
I_m + Q_m \le V_m \\
Q_m \le G\max_{mi} \\
Q_m \ge G\min_{mi}
\end{cases} \tag{11}
$$

Constraints (11) indicate: The sum of the existing inventory and order batches in storage and distribution base m can not exceed its storage capacity. The order batches of m can not exceed the maximum transport capacity. The order batches of m can not be less than the minimum transport unit.

The total allocation costs function at time t in the storage and distribution bases system is given by (12, 13, and 14):

$$
\begin{aligned}
TTD_2 &= OCD_2 + \sum_{m=1}^{M} \left[HCD_m \times t \times \sum_{D_m \le I_m + Q_m} (I_m + Q_m - D_m) \times P_m(D_m) \right. \\
&\quad \left. + \sum_{\substack{k=1 \\ k \ne m}}^{M} \eta(Q_{mk}) \times TCD_{mk} \times Q_{mk} \right] \\
&= OCD_2 + \sum_{m=1}^{M} \left[HCD_m \times t \times \int_0^{I_m+Q_m} (I_m + Q_m - x) \times \frac{1}{\sqrt{2\pi t}\sigma_m} e^{-\frac{(x - t\mu_m)^2}{2t\sigma_m^2}} dx \right. \\
&\quad \left. + \sum_{\substack{k=1 \\ k \ne m}}^{M} \eta(Q_{mk}) \times TCD_{mk} \times Q_{mk} \right]
\end{aligned} \tag{12}
$$

$$
\eta(x) = \begin{cases} 1 & x > 0 \\ 0 & x \le 0 \end{cases} \tag{13}
$$

$$
Q_m = \sum_{\substack{k=1 \\ k \ne m}}^{M} Q_{mk} \tag{14}
$$

The constraints when storage and distribution bases allocates are:

$$
\begin{cases}
0 < I_m + Q_m \le V_m, \textit{When allocating in} \\
-(I_m - RD_m) < Q_m < 0, \textit{When allocating out} \\
|Q_{mk}| \le G\max_{mk} \\
|Q_{mk}| \ge G\min_{mk}
\end{cases} \tag{15}
$$

Constraints (15) show: The sum of the existing inventory and allocating batches in storage and distribution base *m* can not exceed its storage capacity. Excluding the batches that allocated out, the existing inventory of storage and distribution base *m* can not be less than the reorder point. The allocating batches between storage and distribution base *m* and storage and distribution base *k* can not exceed the maximum transport capacity. The allocating batches between *m* and *k* can not be less than the minimum transport unit.

The total inventory costs function of the storage and distribution bases system at time t is referred in (16):

$$TTD = \eta\left(\sum_{m=1}^{M} RD_m - \sum_{m=1}^{M} I_m\right) \times TTD_1 + \eta\left(\sum_{m=1}^{M} I_m - \sum_{m=1}^{M} RD_m\right) \times TTD_2 \tag{16}$$

The reorder point function of storage and distribution base m is referred in (17):

$$RD_m = LT_m \times \mu_m + SS_m = LT_m \times \mu_m + z_m \times \sqrt{LT_m} \times \sigma_m \tag{17}$$

The total order point function of the storage and distribution bases system is referred in (18):

$$RD_0 = \left(\frac{1}{M}\sum_{m=1}^{M} LT_m\right) \times \sum_{m=1}^{M} \mu_m + z_0 \times \sqrt{\frac{1}{M}\sum_{m=1}^{M} LT_m} \times \sqrt{\sum_{m=1}^{M} \sigma_m^2} \tag{18}$$

2.3 Mathematical Model 3: Overall Model

By the costs analysis above, an overall mathematical model which is a distributed multi-echelon inventory control model in coal supply chain is achieved, taking total inventory costs minimum as the goal. The objective function is referred in (19):

$$Min\,(TTR + TTD) = Min\left\{\begin{array}{l} \delta\left(\sum_{n=1}^{N} RR_n - \sum_{n=1}^{N} I_n\right) \times TTR_1 \\ + \delta\left(\sum_{n=1}^{N} I_n - \sum_{n=1}^{N} RR_n\right) \times TTR_2 \\ + \eta\left(\sum_{m=1}^{M} RD_m - \sum_{m=1}^{M} I_m\right) \times TTD_1 \\ + \eta\left(\sum_{m=1}^{M} I_m - \sum_{m=1}^{M} RD_m\right) \times TTD_2 \end{array}\right\} \tag{19}$$

3 Methodology

The distributed multi-echelon inventory control model in coal supply chain based on minimizing the cost in this paper is a non-linear programming problem and the searching space of solutions is wide. Considering the strong function in optimization of the genetic algorithm, this method is selected to solve the problem in this paper [16]. In addition, all algorithms were coded by C Programming Language in the circumstance of VC 6.0 to solve the problem.

4 Computational Experience

Assume that a coal supply chain includes one storage and distribution base and three regional distribution centers as the center. In which, the external supply source consists of several coal production enterprises located in the same area, and the need of each regional distribution center represents the whole demand in this area. The demand in each area is independent and identically distributed, and the demand per unit time obeys the normal distribution, ignoring the effect on the coal demand by the price.

4.1 Setting Parameters

The safety factor is the standard normal distribution function depending on the service level. The values of safety factor corresponding to different service levels are shown in Table 1. The service level can not less than 98 % in regional distribution centers and storage and distribution bases. The expectation and variance of the coal daily demand, lead time, and the related inventory costs are shown in Table 2.

4.2 The Results Analysis of Ordering Model

In ordering model, the comparison of optimal ordering scheme obtained by distributed multi-echelon control strategy based on information coordinating center and traditional coal inventory control strategy is indicated in Table 3. When the sum of the initial inventory of all regional distribution centers is less than the reorder point, total inventory cost of coal supply chain reduces 5.9 % if adopting distributed multi-echelon control strategy.

Table 1 Safety factor in different service levels

SL	90 %	91 %	92 %	93 %	94 %
SF	1.29	1.34	1.41	1.48	1.56
SL	95 %	96 %	97 %	98 %	99 %
SF	1.65	1.75	1.88	2.05	2.33

Table 2 Parameters of distribution centers and base

Parameters	R_1	R_2	R_3	D
Expectation of daily demand μ_n (million tons/100)	3.2	2.7		9.4
Standard deviation of daily demand σ_n (million tons/100)	0.7	0.9	0.5	1.2
Fixed order cost *OC* (million Yuan/100/times)	2.5	2.5	2.5	3
Storage cost *HC* (Yuan/tons * days)	1.3	1.3	1.3	0.6
Transport cost *TC* (Yuan/tons)	9	10	10	12
Lead time *LT* (days)	3	4	4	6
Stock-out cost *PC* (Yuan/tons)	150	150	150	150
Maximum storage capacity *V* (million tons/100)	31	33	29	97
Minimum transport unit $G_{\min}$ (million tons/100)	3	3	3	7
Maximum transport capacity $G_{\max}$ (million tons/100)	15	15	15	15
Service level *SL*	98 %	98 %	98 %	98 %

Table 3 Comparison of optimal scheme in ordering model

Control strategy	Reorder quantity	Total cost
Distributed multi-echelon control strategy	(13.4,12.6,9.1,15)	640.4
Traditional coal inventory control strategy	(15,13.1,10.3,15)	680.9
Percentage of total inventory cost reduction		5.9 %

Table 4 Comparison of optimal scheme in allocating model

Control strategy	Allocating batches	Total cost
Distributed multi-echelon control strategy	(−8.4, −3,11.4)	109.9
Traditional coal inventory control strategy	(0,0,14.8)	164.5
Percentage of total inventory cost reduction		33.2 %

4.3 The Results Analysis of Allocating Model

In allocating model, the comparison of optimal allocating scheme obtained by distributed multi-echelon control strategy based on information coordinating center and traditional coal inventory control strategy is indicated in Table 4. When the initial inventory of several regional distribution centers is less than the reorder point, and the sum of the initial inventory of all regional distribution centers is greater than the total reorder point, total inventory cost of coal supply chain reduces 33.2 %.

5 Conclusion and Future Research

In this paper, the coal supply chain inventory system was regarded as a distributed multi-echelon inventory system consisting of node enterprises in many different industries, with the application of multi-level supply chain inventory control theory and combination with the actual situation of China's coal supply chain. Then explore the coal inventory control problem from the overall perspective of multi-echelon inventory in the supply chain, and the main conclusions are as follows: Firstly, the article has analyzed the overview of the coal supply chain and the current situation of coal inventory management, and then pointed out the problems. Secondly, the coal supply chain structure model of regional distribution centers and storage and distribution bases-centered has been defined, and distributed multi-echelon inventory control strategy in coal supply chain has been proposed, which cause that distributed inventory system formed a virtual concentrated inventory system, reduce the uncertainty in the coal supply chain and eliminate the information island phenomenon in the supply chain. Thirdly, this article established a conceptual and mathematical model, which was distributed two echelon inventory control model in coal supply chain, taking total inventory costs minimum in a certain customer service level as the goal. Fourthly, this paper calculated the concrete example by distributed two echelon inventory control strategy based on information coordinating center and traditional coal inventory control strategy separately. The comparing results confirmed the effectiveness and feasibility of the model and algorithm.

For the inadequacies of this thesis, future theoretical research and practical application needs further study. Research on the coal supply chain uncertainty in depth, such as the coal supply chain robustness, flexibility mechanisms of the coal price, coal transport prices uncertainty etc. Think deeply about government regulation mechanisms, such as the price intervention of government, transport strategy etc.

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Design of the Quality Management System for Manufacturing Workshop Based on the Internet of Things

Qian-hong Yu, Hai-ping Zhu, Hong-cheng Yu, and Yun-jie Feng

Abstract The data collecting of the existing quality management systems (QMS) is generally not real-time, unintelligent and insufficient for quality analysis. A QMS based on the technology of Internet of Things (IOT) is proposed to make up for the drawbacks. We construct a wireless communication network using ZigBee technology for quality information transmission. The devices such as cc2530 chips are used to design the system hardware and .net platform is adopted in the software design. The QMS in this paper is more efficient and reliable, compared with the traditional system.

Keywords IoT • Quality management • ZigBee

1 Introduction

A high level of quality management system could greatly enhance the competitiveness of enterprises [1, 2]. Quality information collection is very important for quality management system of manufacturing enterprises. That is why we require real-time, automatic collection of the quality information in the manufacturing process and process-oriented dynamic online monitoring.

The wired data acquisition of quality existing management system is inefficient and inflexible on account of artificial collecting data [3]. In recent years, with the vigorous development of microelectronic technology, sensor technology, wireless sensor networks, radio frequency identification technology, the Internet of Things (IoT) emerges at a historic moment [4–6]. IoT has the characteristics of

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comprehensive sensing, reliable data transmission and intelligent data processing [7–10]. These characteristics make IoT very suitable for application in the quality management system of manufacturing enterprises.

Combining with the advantages of IoT and manufacturing enterprise's environment, this paper established a quality management system which is based on IoT for manufacturing enterprises, allowing quality engineers to monitor the quality of the products in real-time, and achieve more accurate control charts.

2 The Overall Design for the System

2.1 System Requirements

In an efficient and reliable quality management system, we need to perceive the relevant real-time information automatically, which is important for product quality monitoring. Therefore, it is necessary to achieve the materials' quality inspection results timely.

As drawing control charts need these basic data, it is essential for statistical process control (SPC) to realize the real-time monitoring for the quality of the products in the fabrication process.

2.2 System Structure

In order to meet the above requirements of an efficient and reliable quality management system, we design the structure shown in Fig. 1. The system consists of three layers: the perception layer, the network layer and the quality management layer.

As shown in Fig. 1, the perception layer is composed of numerous ZigBee sensor nodes. These nodes are distributed in the workshop, including the material warehouse, the production lines and the product inspection stations, to collect quality-related data and monitor the related statuses. The network layer is made up of some ZigBee route nodes, a ZigBee gateway and a web server. ZigBee route nodes maintain the routing table and transmit data in the ZigBee network. ZigBee gateway establishes the ZigBee network and manages the network. The ZigBee gateway communicates with the web server via Ethernet. The ZigBee gateway uploads the quality-related data collected by the ZigBee sensor nodes to the web server and receives commands from it. After receiving data from the ZigBee network, the web server converts the heterogeneous data into a standard format by data fusion and then stores them into database.

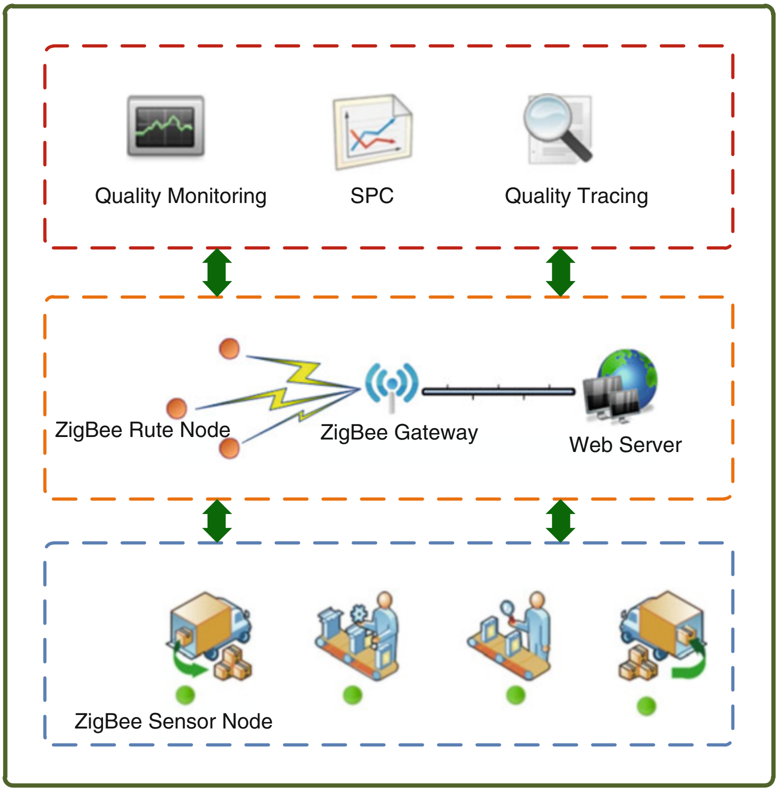

Fig. 1 Structure of the quality management system

3 Hardware Design

In order to satisfy the requirements of the quality management system, we choose CC2530 provided by Texas Instruments as the primary chip. CC2530 supports Z-Stack2007 and is able to establish various topology types of network, which is a real system on chip. CC2530 integrates an enhanced 8,051 μ control unit, AD converter, UART, etc. [11, 12]. With power consumption and industrial-grade anti-jamming capability, and the aid of some simple peripheral circuits CC2530 can meet many application requirements.

3.1 ZigBee Gateway

The ZigBee gateway establishes the ZigBee network and controls the network. The ZigBee gateway uploads the quality-related data collected by the ZigBee sensor

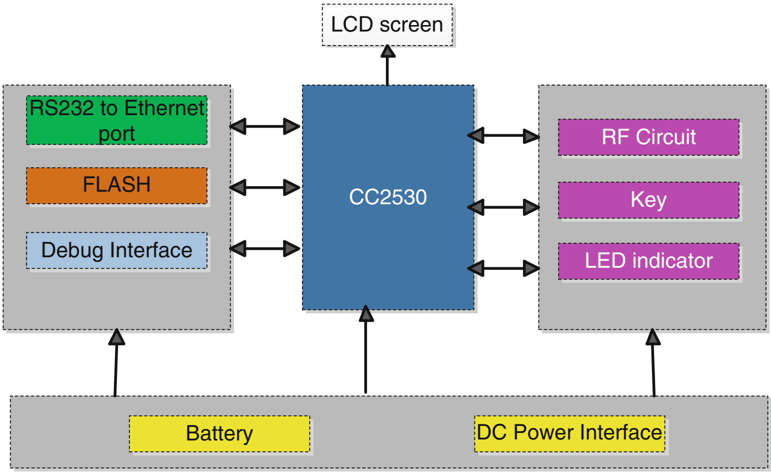

Fig. 2 Structure of the ZigBee gateway

nodes to the web server and receives commands from it. The ZigBee gateway is composed of CC2530, radio frequency circuit, RS232 to Ethernet module, power management circuit, etc. The hardware structure is shown in Fig. 2. The radio frequency circuit is used for transmitting and receiving wireless data packages. The only mechanism of communication with the web server is via the RS232 to Ethernet module.

3.2 ZigBee Route Node

The ZigBee route node's main task is to maintain the routing table and transmit data throughout the whole ZigBee network. The ZigBee route node's structure is simple, which is composed of CC2530, radio frequency circuit, power management circuit, etc.

3.3 ZigBee Sensor Node

The ZigBee sensor nodes are the nerve endings of the ZigBee network. The ZigBee sensor node is composed of CC2530, radio frequency circuit, the analog signal input circuit, the digital signal input circuit, the buzzer circuit, etc. The hardware structure is shown in Fig. 3. The ZigBee sensor nodes are connected with digital calipers via USB port to get the readings of the digital calipers. The ZigBee sensor nodes are connected with mechanical equipment via RS232 to monitor their running status.

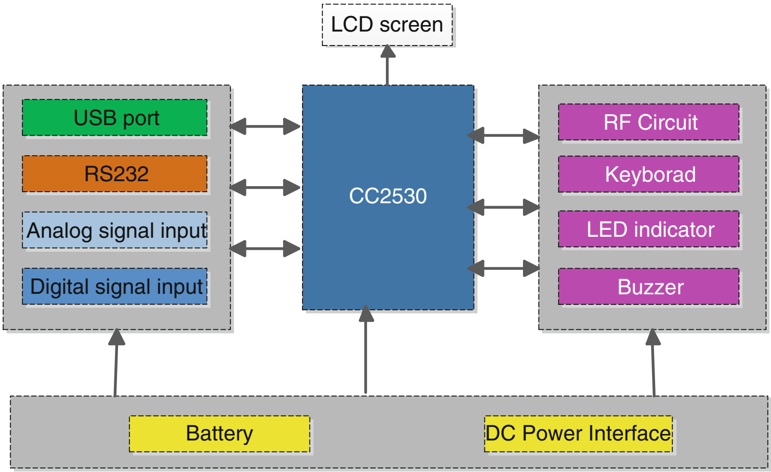

Fig. 3 Structure of the ZigBee sensor node

4 Firmware Design

Considering the characteristics of CC2530, we choose Z-Sack2007 as software platform to design firmware for the ZigBee nodes. Z-Sack supports star-type, tree-type, mesh-type topologies, and has many advantages such as: safe and reliability, low latency, large network capacity, etc. [13–15]. Therefore, it is quite satisfied with the requirements of the system.

4.1 ZigBee Gateway

The ZigBee gateway establishes the ZigBee network and controls the network. The ZigBee gateway uploads the quality-related data collected by the ZigBee sensor nodes to the web server and receives commands from it. The workflow of the ZigBee gateway is shown in Fig. 4. When the ZigBee gateway has successfully established the network, it will get into circulation mode. The ZigBee gateway assigns addresses for other nodes to join the network and manages these addresses.

4.2 ZigBee Route Node

The main task of the ZigBee route node is to maintain the routing table and transmit data throughout the whole ZigBee network. The workflow of the ZigBee route

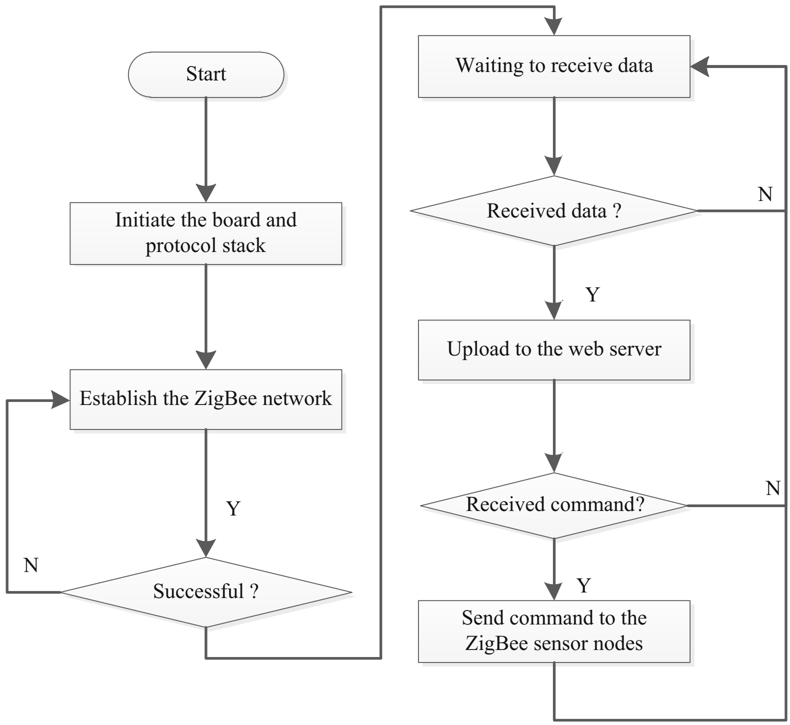

Fig. 4 Flow chart of the ZigBee gateway

node is shown in Fig. 5. After power on, the ZigBee route node first initializes the hardware and the protocol stack, and then begins to search the ZigBee network that can be joined.

4.3 ZigBee Sensor Node

The ZigBee sensor nodes are the nerve endings of the ZigBee network. As the nerve endings of the IoT, the primary assignment of ZigBee sensor nodes is to collect relevant data in real-time and automatically. The workflow of the ZigBee route node is shown in Fig. 6. After the initiation of the board and protocol stack, the ZigBee sensor nodes search Zigbee network to join. Once it has joined the network, it will pack data and upload to the web server.

The sensing targets of the ZigBee sensor nodes are various. The ZigBee sensor node connected to the RFID reader is used to collect the quality inspection data of materials in the warehouse district. In the mechanical processing zone, the ZigBee sensor node connected to the numerical control machine reads machine status. In the quality inspection area, the ZigBee sensor node connected to the digital measurement tools collects their readings.

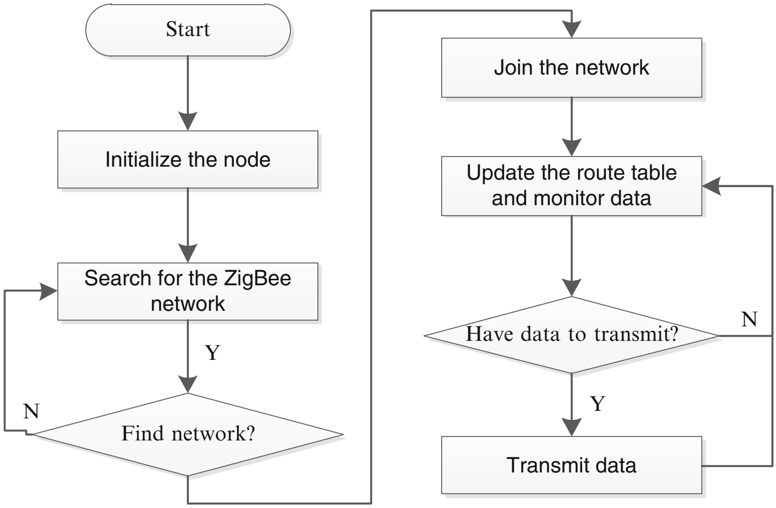

Fig. 5 Flow chart of the ZigBee route node

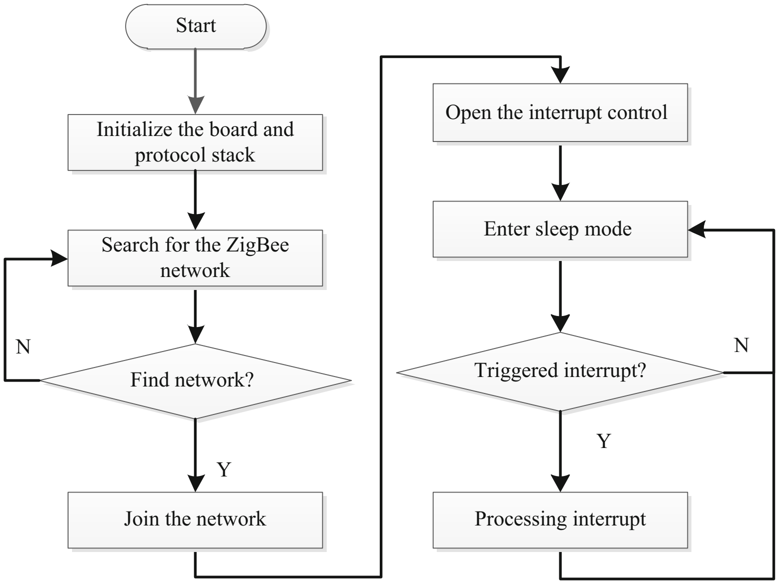

Fig. 6 Flow chart of the ZigBee sensor node

5 Quality Management System Based on the Internet of Things

Consideration of web service, we develop the quality management system on the .net platform, installed on the web server. The service platform has two functional modules.

1. Data processing module. The sensing targets of the ZigBee sensor nodes are various, which results in the complex structures of the original data. We exploit huge numbers of ZigBee sensor nodes to collect data, which leads to serious data redundancy. The primary task of the data processing module is to eliminate the above problems. The data processing module using data fusion techniques is used to eliminate redundant data, using data transformation to obtain the data with uniform data format.
2. Quality management module. With the aid of further data analysis and processing, quality management module provides quality monitoring, quality tracing, and SPC for quality engineers. The interface of the system is shown in Fig. 7. The system interface consists of three areas, the area of the raw data, the area of the information tree associated with quality, the area of SPC chart.

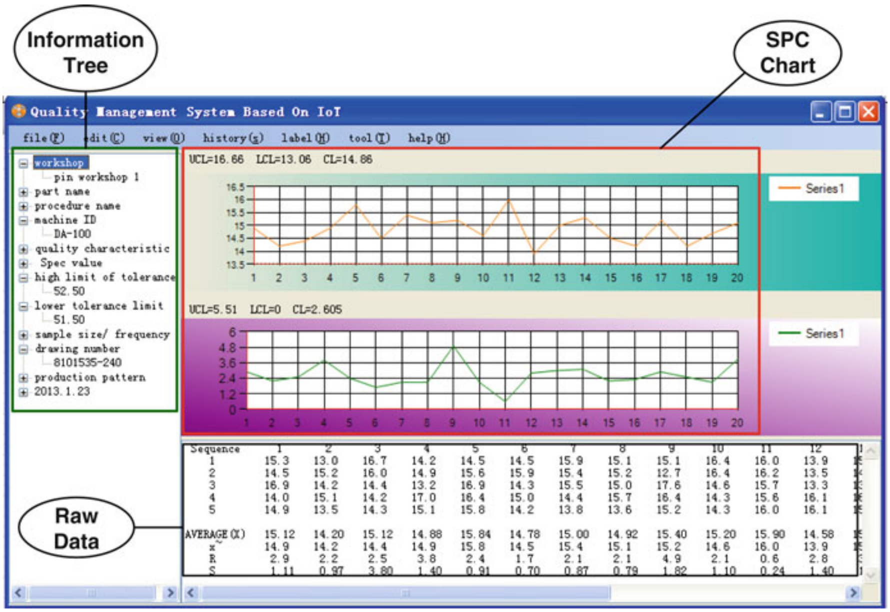

Fig. 7 Interface of the system

6 Conclusion

In order to improve the efficiency and reliability of the quality management system, this paper introduces IoT technology especially ZigBee into monitoring procedures and designs the quality management system based on IoT adapting to the manufacturing environment. The system has following advantages.

Using intelligent sensing technology of WSN and automatic identification technology of RFID, the quality management system could be more efficient and accurate.

Compared with conventional systems, it costs less and is easier to deploy.

These essential functions have been accomplished. Some other expected functions would be the future research emphasis.

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Modeling and Analysis of the Manufacturer Model of Closed-Loop Supply Chain

Le Ma, Yi Chai, and Rong-rong Zhu

Abstract This paper studies uncertain demand by a supplier and manufacturer two echelon closed-loop supply chain system model setting up and solving the problem, gets the manufacturers to control the transfer function of the z-domain expression and manufacturer System Model solving analysis. Sensitivity analysis of the model parameters, and comes to different parameters of the closed-loop supply chain model.

Keywords Closed-loop supply chain • Simulation • The manufacturer • The transfer function

1 Introduction

The closed-loop supply chain is the inevitable outcome of the economic and social development. It is on the basis of the traditional forward supply chain, integrated reverse supply chain business processes [1–3]. This paper studies a supplier and manufacturer two echelon closed-loop supply chain system model uncertain demand, to set up and solve problems through the use of cybernetics, to create a closed-loop supply chain model, and to analyze the sensitivity of the model parameters, such as the impact of parameter settings for closed-loop supply chain model.

There are a lot methods of solving a closed loop supply chain model [4–11], the structure in solving complex matter of time compared to traditional methods such as dynamic programming, control theory in the reaction system has obvious advantages: First, control theory in domain transform techniques can solve the

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problem of the time domain into discrete z domain or a continuous domain of s solving to avoid the problem of solving the high equation and the exponential function; Second, control theory is used to analyzed block diagram showing the structure of the system can make it more clearly understand the relationship between the various components of the system, and each variable, and to make the system more simple and intuitive [12]. Sui [12] obtained the transfer function of the closed-loop supply chain system, and analyze the bullwhip effect; Zhao [13] using two echelon closed-loop supply chain system consisting of a manufacturer and a supplier control theory modeling and simulation, and remanufacturing activities are based on analysis of closed-loop supply chain. This article will learn and improve the domain model based on the sensitivity analysis of the model parameters.

2 Model Assumptions and Parameter Description

Two echelon closed-loop supply chain model composed by a manufacturer and a supplier, the manufacturer, in addition to through two ways to suppliers and production of new products, but also by remanufacturing added salable goods inventory. Its product life cycle is reached, the product will be in accordance with a certain proportion of manufacturers recycle [7, 9].

2.1 Model Assumptions

The basic assumption of this paper is as follows:

1. A recycled product after the detection, treatment, re-manufacturing, and new products are identical in functionality, quality and usefulness.
2. In each cycle, each node of the supply chain enterprise needs of the market demand forecasts, and current production/procurement plan based on projected demand information and inventory information.
3. Recovered checked the quality remanufacturing permission, otherwise scrap processing, recycling and remanufacturing activity there is no time delay problem.
4. Manufacturer periodic inventory of their own goods inventory strategy, a series of factors of production/procurement quantity and manufacturer inventory count cycle, the average demand during lead production, safety stock amount.
5. According to the actual situation, not all products to its life cycle can be successfully recovered, also not all recycling back products can be remanufactured, it is necessary to carry out the two probability assumptions set recoveries recycled products remanufacturing rate.
6. Assumptions of the manufacturer, the new product production lead time is less than the lead again products, thus ensuring the manufacturer fully informed again product information, ease of production decisions.

Table 1 Model parameter description

d	Market demand	CR	Recovery rate
α_i	Exponential smoothing constant	RR	Remanufacturing rate
$\hat{d}_i$	The predictive value of the market demand	cu	The number of recycling waste products
O_i	Production of new products	τ	The number of end-of-life waste products
r_m	The number of remanufactured products	t_{eol}	Product life cycle
L_{pi}	New product production lead time	$INVP_i$	Inventory levels
L_r	Remanufactured production lead time	WIP_i	Production inventory in-process channels
k_i	Safety stock lead time	$AINVS_i$	Actual inventory
P_i	Purchase volume of new products	WIR_i	The manufactured inventory of recycling channels
L_{w_i}	Delivery time after ordering	OAP_i	The production and order quantity

2.2 Parameter Description

Table 1 shows the model parameters is defined, where $i = 1$ indicates the manufacturer, and $i = 2$ represents a supplier.

3 Manufacturer System Model for Closed-Loop Supply Chain Under Demand Uncertainty

Two echelon closed-loop supply chain systems consisting of a manufacturer and a supplier, the manufacturer of the system to add the product recycling and remanufacturing and other activities, the manufacturer of the system transfer function model becomes more complex. From the demand forecast, inventory levels, the production/ordering strategy, product remanufacturing four aspects to consider its transfer function sub-model, and its z-transform respectively, concluded the key system variables between the z-domain expressions.

3.1 Mode Establishment

3.1.1 Demand Forecast

For manufacturers, whether the production plans or parts procurement plans are based the forecast on the basis of good market demand, taking into account the characteristics of the system data exists volatility, but no significant growth trend, using exponential smoothing method to predict demand, exponential smoothing formula is as follows:

$$\hat{d}_1(t) = \alpha_1 d_1(t-1) + (1-\alpha_1)\hat{d}_1(t-1) \tag{1}$$

Do z-transform,

$$\hat{d}_1(z) = \frac{\alpha_1 z}{z-(1-\alpha_1)} d_1(z) \tag{2}$$

3.1.2 Inventory Levels

Inventory levels is the current actual of manufacturers, salable product inventory by the manufacturer of the current actual inventory levels, inventory of salable goods manufacturers by the production of new products, manufacturers sourcing channels generated sales goods inventory and manufacturers remanufacturing channels generated four channels of in-process inventory, according to the literature [14] studies, the time domain expression is as follows:

$$INVP_1(t) = AINVS_1(t) + WIP_1(t) + WIS_1(t) + WIR_1(t) \tag{3}$$

Among them,

$$AINVS_1(t) = AINVS_1(t-1) + O_1\left(t - L_{p1}\right) + P_1(t - L_{w_1}) + r_m(t - L_r) - d_1(t) \tag{4}$$

$$WIP_1(t) = WIP_1(t-1) + O_1(t) - O_1\left(t - L_{p1}\right) \tag{5}$$

$$WIS_1(t) = WIS_1(t-1) + P_1(t) - P_1(t - L_{w_1}) \tag{6}$$

$$WIR_1(t) = WIR_1(t-1) + r_m(t) + r_m(t - L_r) \tag{7}$$

Do z-transform,

$$AINVS_1(z) = \frac{1}{1-z^{-1}}\left(O_1(z)^* z^{-L_{p1}} + P_1(z)^* z^{-L_{w1}} + r_m(z)^* z^{-L_r} - d_1(z)\right) \tag{8}$$

$$WIP_1(z) = \frac{1}{1-z^{-1}}\left(O_1(z) - O_1(z)^* z^{-L_{p1}}\right) \tag{9}$$

$$WIS_1(z) = \frac{1}{1-z^{-1}}\left(P_1(z) - P_1(z)^* z^{-L_{w1}}\right) \tag{10}$$

$$WIR_1(z) = \frac{1}{1 - z^{-1}} \left(r_m(z) - r_m(z)^* z^{-L_r} \right) \tag{11}$$

3.1.3 The Production/Order Strategy

Inventory of salable goods manufacturers in the development of production and order policy, on the one hand, the market demand forecasts, on the other hand should be already taken into account. According to the study of the literature [15, 16], the current the production/ordering policy can be expressed as:

$$OAP_1 = \left(1 + L_{p1} + k_1\right)^* \hat{d}(t) - INVP_1(t) \tag{12}$$

3.1.4 Product Remanufacturing

Actual situation shows that not all reaches the life cycle of the product can be recovered, and the recovered product is also not able to be re-manufactured according to previous assumptions, it is assumed that recovery rate CR is, recovering product remanufacturing rate RR domain expression after t_{eol} time and then the quantity of product r_m can get:

$$r_m(t) = CR^* RR^* d\,(t - t_{eol}) \tag{13}$$

Do z-transform,

$$r_m(z) = CR^* RR^* d(z)^* z^{-t_{eol}} \tag{14}$$

3.1.5 Transfer Function Model Between the Key Variables

Manufacturers will choose to produce and purchase volume and as a system of charged amount, the value of the market demand as the system for a given value, the task of the control system is to make both a dynamic equilibrium. Therefore, the manufacturers, to establish the model of the transfer function between the key variables, that is established between OAP_1 and d_1, the z domain expression. Previous the production/procurement analysis, we can know, current the production/procurement of new products quantity $O_1(t)$ time domain expression:

$$OAP_1(t) = \left(1 + L_{p1} + k_1\right)^* \hat{d}(t) - INVP_1(t) \tag{15}$$

Do z-transform,

$$OAP_1(z) = \left(1 + L_{p1} + k_1\right)^* \hat{d}(z) - INVP_1(z) \tag{16}$$

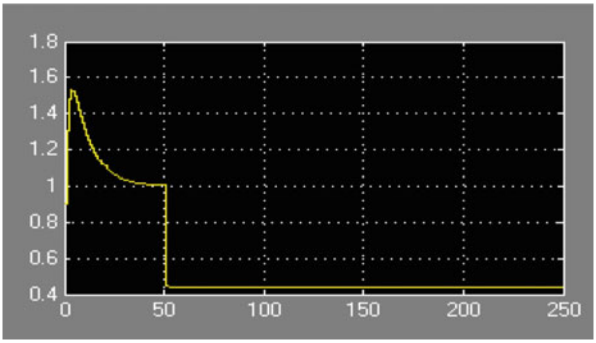


Fig. 1 Closed-loop supply chain manufacturers subsystem dynamic simulation image

Eq. (1) into (14) and simplifying, we obtain:

$$OAP_1(z) = \left((1 + L_{p1} + k_1) \frac{\alpha_1 z}{z - (1 - \alpha_1)} + \frac{z}{z-1} - \frac{z}{z-1} {}^* CR^* RR^* z^{-t_{eol}} \right) {}^* \frac{z-1}{2z-1} {}^* d_1(z) \tag{17}$$

3.2 MATLAB Simulation Analysis

In this simulation, the parameters to be set to:

$$\alpha_1 = 0.1, L_p = 6, k_1 = 1, CR = 0.8, RR = 0.7, t_{eol} = 50$$

The above parameter values are substituted into Eq. (17) to give the transfer function z-domain expression:

$$OAP_1(z) = \left(\frac{0.8z}{z-0.9} + \frac{z}{z-1} - \frac{0.56z}{z-1} {}^* z^{-50} \right) {}^* \frac{z-1}{2z-1} {}^* d(z)$$

Matlab simulink tools for dynamic simulation of the two closed-loop supply chain system, the results shown in Fig. 1.

Traditional forward supply chain compared to the closed-loop supply chain system just less product recycling and re-manufacturing process, so that $CR = 0$, come to the z-domain expression of the transfer function of the traditional closed-loop supply chain:

$$OAP_1(z) = \left((1 + L_{p1} + k_1) \frac{\alpha_1 z}{z - (1 - \alpha_1)} + \frac{z}{z-1} \right) {}^* \frac{z-1}{2z-1} {}^* d_1(z)$$

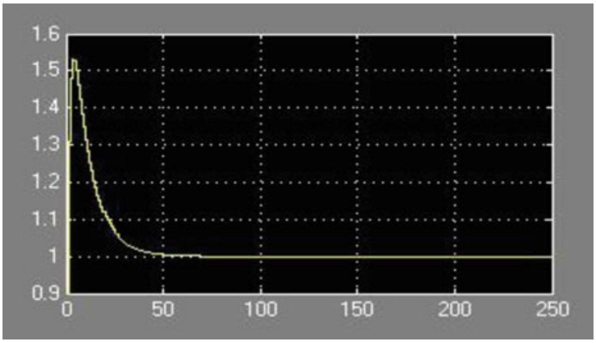


Fig. 2 Manufacturers of traditional forward supply chain system dynamic simulation image

To contrast with the front of the closed-loop supply chain model is still the parameter value is set to:

$$\alpha_1 = 0.1, L_p = 6, k_1 = 1, t_{eol} = 50$$

Matlab simulink tools of traditional forward supply chain system dynamic simulation, the results shown in Fig. 2.

3.3 Traditional Forward Supply Chain and Comparative Analysis of the Simulation Results of the Two Echelon Closed-Loop Supply Chain

Compare Figs. 1 and 2 can be obtained the following conclusions:

Remanufacturing activities supplemented manufacturer's salable product inventory, and a decrease in the sum of manufacturer's production and purchase volume OAP_1. The supplier market demand will be reduced; it will also bring about a reduction in the amount of the production and procurement of suppliers.

Fifty weeks, reaching the product life cycle of the product is recycled for re-manufacturing activities, and assume that the process of recycling and re-manufacturing is no time delay, the manufacturers of new products production and purchase volume and instantly dropped, and maintain in a stable value.

Remanufacturing activities had no significant effect on the dynamic performance of the control system, and also no significant difference in the system overshoot.

From the above analysis, the difference between traditional forward supply chain systems with closed-loop supply chain system is significant, and the product reaches its life cycle, the initial investment market products effectively recycling manufacturing, so there will be decision variables the moment reduced. Traditional forward supply chain system, a dynamic equilibrium, production/purchase volume and market demand in a closed-loop supply chain system, the amount of production,

Fig. 3 $\alpha_1 = 0.1$

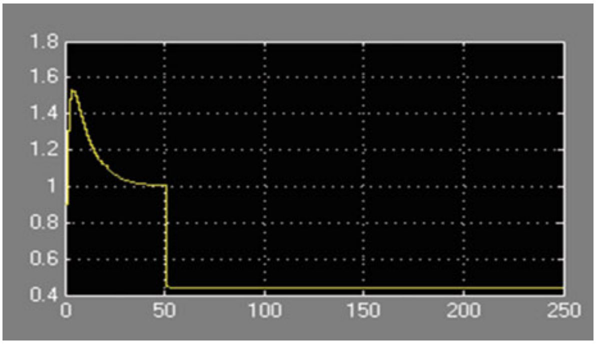
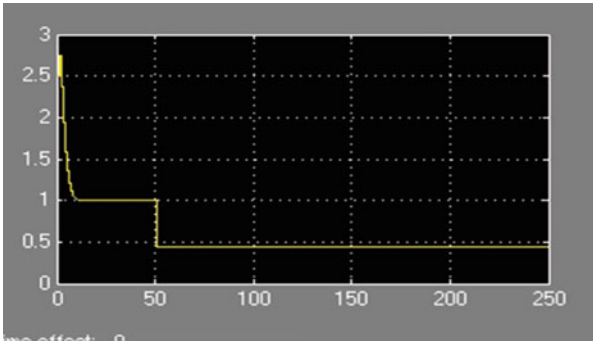


Fig. 4 $\alpha_1 = 0.5$



purchase volume by remanufacturing salable goods inventory and market demand of the three parts of a dynamic equilibrium, which is consistent with the previous theoretical analysis.

4 System Sensitivity Analysis

Analyze the sensitivity of the system parameters of the manufacturer, and to draw conclusions of the simulation image.

4.1 The Impact of Exponential Smoothing Index Model

Respectively assign a different value to $\alpha_1 = 0.1, 0.5, 0.9$, the simulation results are as follows:

Analyzing Figs. 3, 4, and 5, with the α value is increased, the dynamic response of the speed of the system increases, the rise time t_r, the delay time t_d, the peak time t_p, adjusting the time t_s is reduced, but the system overshoot amount

Fig. 5 $\alpha_1 = 0.9$

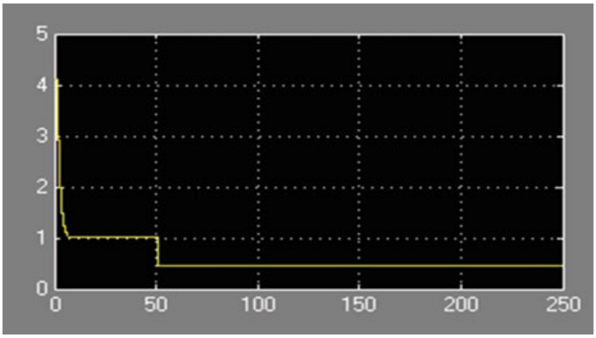
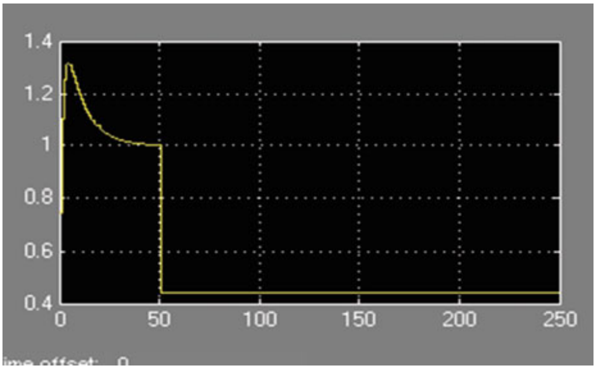


Fig. 6 $L_p = 3$



increased. According to the definition of σ_p, it is the size of the characterization of the Current demand forecast value by the size of the impact of the previous period actual observations, analysis can be seen from the graphic, the current exponential smoothing demand more predictive values depend on the period of actual observations, the supply chain model the dynamic response of the faster, more intense oscillation.

4.2 The Impact of New Product Production Lead Time and Safety Stock Lead Times to the System

According to the transfer function expression, change the new product lead time and safety stock lead times is the same effect on the system, so the new product lead times model in this studies.

Respectively assign a different value to the $L_p = 3, 6, 9$, the simulation results are as follows:

Analyzing of Figs. 6, 7, and 8 the new production lead times L_p did not significantly affect the dynamic response speed of the system, but its system overshoot significantly affect That, along with the production of new products lead

Fig. 7 $L_p = 6$

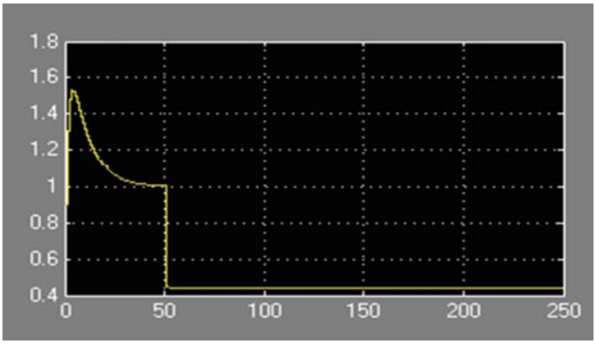
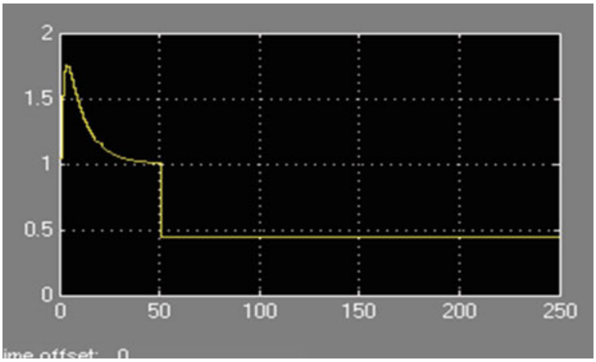


Fig. 8 $L_p = 9$



times increase, will bring greater volatility is unfavorable for the closed-loop supply chain system for closed-loop supply chain system. Therefore, manufacturers should look for the advance period lead times and safety stock method to shorten the new product.

4.3 The Impact of Waste Product Recovery and Remanufacturing Rate on the Closed-Loop Supply Chain System

According to the transfer function expression, the impact of the recovery rate of waste products A and remanufacturing rate B to closed-loop supply chain system is the same, so consider the impact of their multiplied.

Respectively assign a different value to the $CR * RR = 0.42, 56, 72$, the simulation results are as follows:

Analysis Figs. 9, 10, and 11, change product recovery and remanufacturing rate on the dynamic performance of closed-loop supply chain system there is no significant impact, but its steady-state indicators have a significant impact, with

Fig. 9 $CR * RR = 0.42$

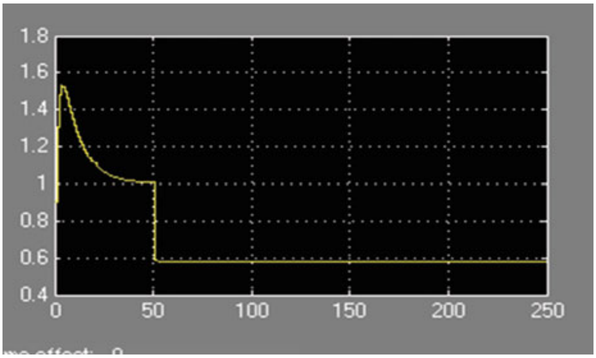


Fig. 10 $CR * RR = 0.56$

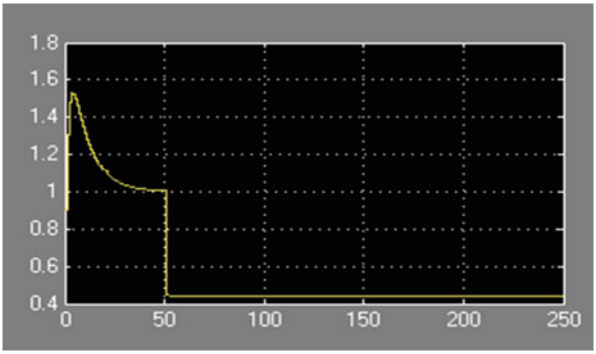
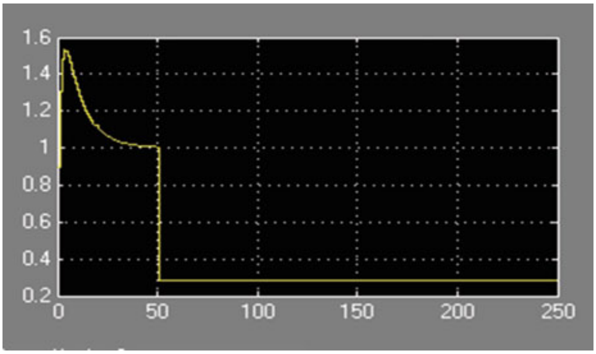


Fig. 11 $CR * RR = 0.72$



the increase in the rate of recovery and remanufacturing system the steady-state output value decreased, which is consistent with reality. In real life, as manufacturers increase the rate of recovery and remanufacturing of recycled products, manufacturers need production and procurement will reduce the number will increase due to the remanufacturing bring salable goods inventory.

5 Conclusion

This article focuses on setting up and solving the problem of the two echelon closed-loop supply chain model composed by a manufacturer and supplier of uncertain demand. System manufacturers to establish transfer function model to determine its domain expression simulink simulation model solving, and comparative analysis with traditional forward supply chain system derived based on closed-loop supply chain system with traditional remanufacturing is to the difference of the supply chain system. Analyzing the sensitivity of the parameters involved in the model, the simulation curve obtained by analyzing the obtained parameters to select the transfer function model of the closed-loop supply chain.

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The Investigation of Standardized Routing Design of Project Logistics Based on the Process Screening Method

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Abstract In order to ensure the safety during the transportation of large-scale equipments and improve transportation method of large-scale equipments based on the experience, and analyze the influence of safety with the factors of human, technology and risk, and improve the predictive ability of risk and the safety coefficient of transportation, CAE technology is applied in large scale equipment transport logistics process in this research. By taking the rolling transportation of the shipping machine for instance, safety analysis and logistics scheme optimization is carried out, and an engineering project logistics standardization routing implementation plan based on the process of screening method is presented to improve the project logistics standard and the safety of the transportation.

Keywords Project logistics • Rolling transportation • Screening process • Shipping machine • Simulation analysis

1 Introduction

Along with the fast development of social economy and engineering technology, the number of large engineering increases rapidly. Because of the large size and great weight characteristics of the large-scale equipments, it is difficult to transport using the land transportation due to the capacity restriction of the road and bridge. Therefore, the Marine transportation mode is widely adopted.

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In order to improve the safety of transportation of large equipment during the maritime transport, the transportation projects of large equipment managements are discussed from the point of view of project logistics considering the combination of advanced management theory and system engineering idea.

Because the large equipment engineering logistics process is complicated, the process of screening method is adopted to optimize logistics solutions. Meanwhile, the advanced computer technology and virtual prototyping technology is used to simulate the key steps in the rolling process, so as to determine the optimal parameters of the cargo.

Taking rolling shipping process of a shipping machine in Marine transportation as an example, this paper proposes a method to optimize the key steps in engineering logistics management. The advanced CAE technical is adapted to analyze the key process in the transportation. Based on a parametric simplified model, the simulation of the attitude of the shipment machine and the load case of weather conditions such as wind are carried out to evaluate and optimize rolling plan.

2 Methodology

2.1 Organization and Implementation of Project Logistics Project

The key equipment is usually giant in major projects. The difficulty in the transportation process is increased significantly due to the high risk, strong limitation, disposable questions etc., because of its over length, super wide, over high and overweight. Researches in engineering logistics theory and practice in recent years provide solutions to the safety and the efficiency in transportations of large equipments [1–6].

2.2 Project Logistics and Its Simulation

Project logistics is an important part of modern logistics. It has obvious difference with traditional products logistics in supply chain characteristics, operation mode, management of the core content, decision-making methods and techniques as well as to the special equipment and technical requirements. It emphasizes the "project" characteristic, including the project implementation disposable, the overall relevance, the uncertainty of the process, the technological complexity, the risk of process, and the key role of solutions to achieve the overall objective of the project.

In order to reduce the risk of this complicated system engineering, the optimization of the simulation must be introduced to perform the analysis, observation and judgment. In this simulation, engineers can preset possible load case to

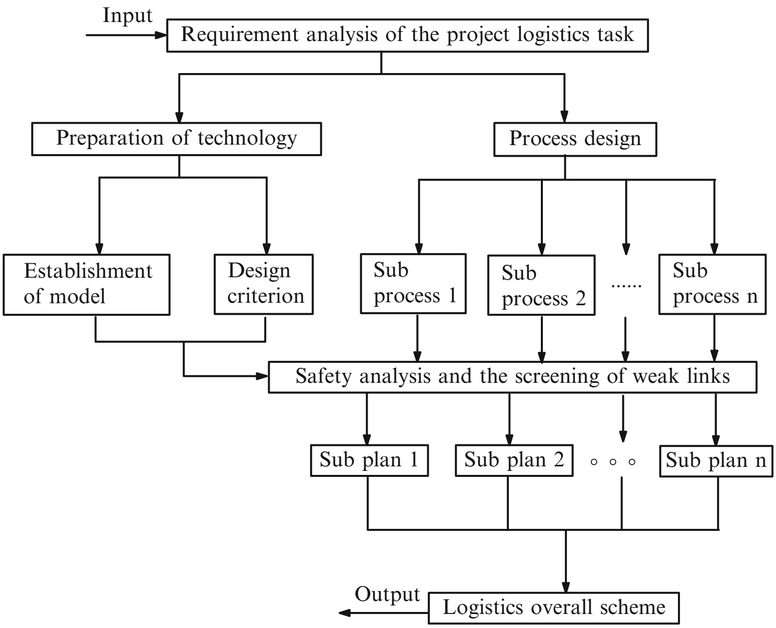

Fig. 1 The schematic diagram of the general scheme design in Logistics engineering

optimize and control the operation process, so as to achieve the improvement of the reliability, optimization of the scheme of key steps, cost savings, and improvement of efficiency.

2.3 *Design of the Project Logistics Scheme Based on the Process of Screening Method*

Most of the traditional engineering logistics is based on the engineering experience with the debugging method to determine logistics technology scheme, generating a great uncertainty in the logistics project and increasing the technical risk. In order to improve overall technical feasibility and effectiveness of the large equipment engineering logistics, process of screening method is introduced to comb each sub-processes in the process design. With this method, different process parameters which Influence the project logistics safety can be predicted. Based on this procedure, the key process parameters can be determined. At the same time, the potential safety hazard can also be evaluated. Furthermore, the related technical scheme will be optimized. In the thought of process design, with the help of advanced CAE technology, the implementation of safety analysis and the troubleshooting of the weak steps can be performed to determine the key process parameters (shown in Fig. 1).

3 Results

Taking the loading machine for instance, the overall scheme of the shipping machine logistics is carried out according to the above design idea of the project logistics. The shipping machine is arranged by transportation batch. There are four shipping machines in each batch; each machine is composed of a main engine and a caboose. The main engine is a four-bar mechanism with a telescopic rotary jib. The main engine includes portal-framed structure, long travel, jib structure and rotating frame. After production-manufacturing, the four shipping machines are transported to customer ports. Then the batch of shipping machines is transported in the way of complete machines by using a seaborne massive pontoon.

3.1 Demand Analysis of the Logistics Tasks of Shipping Machines

According to the characteristics of the equipment and terminal equipment allocation, the cabooses are transported by hoisting process. Meanwhile, the main engines are transported by rolling process. Considering the factors in the project progress, technical resource allocation and barge carrying capacity etc., the whole project is divided into three voyages. The first voyage will ship the four sets of cabooses, the second and the third voyage will ship two sets of main engines. In the organization and implementation process, the logistics project management organization, the preparation of transportation project progress plan (including batch schedule), the quality control of construction projects and the implementation of the project risk management must be established. Furthermore, CAE and virtual prototyping technology are used to simulate the key steps in the cargo loading and unloading process and the shipping process. The burst-interference caused by the variation of climate and hydrology must be calculated and then evaluated. Moreover, the troubleshooting and prediction of weak links in the shipping machine are as important as the formulation of contingency plans. Above all, every detail of the implementation must be monitored to ensure the safety of the project smoothly.

3.2 Technological Preparation Before the Simulation of Project Logistics

Because of the complexity of the structure of the Large Scale Equipment in Project Logistics, technical pre-simulation processing is necessary for the critical links in logistics. In the pre-simulation processing, the complex structure of the shipping machine is simplified according to the actual condition as much as possible. In the shipping machine rolling project, the simplification of the modeling parameters and the attitude control of the machine are a necessary preparation for the simulation and the formulation of the Rolling scheme.

3.2.1 The Digit Model of the Large Scale Equipment

Modeling of the finite element method for the large object is necessary before the simulation analysis of the logistics project. However, the shipping machine is a complex mechanical system with various components, structures of large scale and complex connection. Therefore, the simplification of the machine is necessary [7–12].

1. *Principle of the simplification*
   Considering the objectivity of the simulation analysis is the overall performance of the machine in the process of cargo on board, it is reasonable that some details of the structures can be ignored or equivalent simplified. There are two kinds of details to be processed: the first one is the simplification of the structural details. Process chamfering, tank, holes of process without affection to the structure strength can be ignored in the modeling. In addition, Screw fastening is treated as rigid connection, and Welding connection is considered as idealized uniform. However, details which will affect the structure strength must not be ignored. The second one is the processing of accessory structures, such as the operator cabin, the electrical control room and the driving mechanism of the Rotating frame. Details like that can be treated as mass elements.
2. *Elements selected in modeling*
   The selection of elements must follow the next three principles: the first one is to ensure sufficient calculation accuracy to meet the requirements of analysis, the second one is to apply loads easily, and the third one is to get convenient intuitive view of the structure in analysis. In the FEM, the beam element is selected to model the slender or medium short beam structure, because it is convenient to control the type, direction and offset of the distributed force. The shell element is selected in the modeling to extract the modal. In addition, the link element is used to simulate the slings and the hydraulic shafts because of its incapacity of the bending moment and torque. Finally, the lumped mass is modeled by using mass element.
3. *Connection processing*
   There are 6 degrees of freedom at each node of shell and beam element. In addition, the two types of elements can share nodes with each other when modeling. Therefore, force and deformation can be transferred through the shared nodes. Multi-point constraints (MPC) must be introduced into the connection points when modeling the connection between beam and shell to avoid the stress distortion [13]. For connection type of Pin hole connection, only the rotational degree of freedom is released at the pin shaft center, the other 5 degree are coupled.

4. *Overall modeling of the machine*
   Before the overall modeling, pre-modeling and pre-analysis are performed by using beam element. After that, models of each part are established. The determination of the dimension and the parameters should be considered during the modeling process that is convenient to adjust and modify.

3.2.2 Design Principles of Rolling Attitude

Because the center of gravity of shipping machines is high, the position of the shipping machine and the distribution of the self-weight will be affected by the rolling attitude. In the plan making of the rolling process, it's considered that the machine must be adjusted to a reasonable attitude to keep the stability of the shipping machine. In this attitude, the center of the gravity should be at a lower position, the load distribution of each part should be uniform, and the demand to the space and the equipment should be much lower.

3.3 Design of Rolling Process of Shipping Machine

According to the loading machine characteristics and transport requirements, the adjustable ballast water semi-submersible barge is used in the cargo transportation. The process can be divided into four sub-steps as follows:

1. *Alignment of rails*
   According to the requirement of the rolling technique, the barge is parked closed to the wharf into a T-shaped position. The attitude of the barge is adjusted to ensure the alignment between the barge cargo rail and shore rolling rail. All the links should be ready for shipment such as laying the rolling approach bridge, tightening the Lashing rope and so on.
2. *Modification of load with traction step by step*
   After checking for the personnel and the equipment, and adjusting the alignment between the deck surface and the terminal level, hoist traction can be started on board. When the first row wheels approaches the barge through the rails, the ship stern begins to sink because of the gravity of the shipping machine. As a result, the barge trims. Then, the ballast water adjustment system begins to adjust the load. During the process of adjustment of load, the adjustment progress can't usually keep up with lighter trim speed because of the tide. When the barge orbit plane height difference becomes more than 50 mm, the traction must be stopped, and the shipping machine should be constrained using temporary fixed facilities, waiting for the ballast water condition to make the orbit plane on both sides back to the level state. In this way, shipping machine will be loaded onto the rolling ship step by step. The same method is also used when discharging the shipping machine step by step.

3. *Drifts away from the wharf*
   When the last row wheels are driving onto the rails on the barge from the rails on the wharf, the shipping machine should stop racing ahead. After that, the ballast water adjustment system began to adjust the load to make the ship bow slightly dipping. At this time, the ship bow is slightly dipped to avoid the big trim of the barge. Finally, the shipping machine should be pulled onto the barge carefully to the designate location.
4. *Jacking into the designate position*
   In order to keep the stability of the shipping machines during the transportation, the machines should be constrained on the fixed rails. After rolling the shipping machine into the designated location, the wheels should be lifted up using the jack, and then rotated 90° prior to laying on the fixed rails.

3.4 Safety Analysis of the Rolling Process and the Screening of Weak Links

The standardization routing design is the premise of risk estimates in the project logistics. The potential risk should be estimated in each step to ensure the safety of the whole project, shown in Fig. 2. In the rolling process, according to the four steps in Fig. 2, the analysis is focused on the traction and lifting process.

3.4.1 Choice of the Rotating Frame Attitude

A rotating frame can make a rotation of 360° around its rotation center. Two limit attitudes of parallel to the X axis (A status) and Z axis (B status) are chosen to calculate the center of gravity of the shipping machine and the stress situation of support columns. Considering the boundary conditions and the gravity, the contour plot of the stress distribution of the support columns can be presented after solution. Under A status, the stress filed of the support columns on both sides is seriously inhomogeneous. The center of gravity is almost in the middle plane parallel to the rails under B status. Furthermore, the stress distribution is uniform in the support columns under B status. Therefore, the B status is chosen in the transportation.

3.4.2 Choice of the Attitude of the Boom System

Different attitudes of the boom system is simulated with its angle from – 6° to + 20° step by step to calculate the maximum deformation, the stress field of each part and the position of the gravity center of the main engine. In each step, the gravity is applied on the model in the static solution to get the contour plot of stresses and deformations of the complete machine. It is found that the deformations and

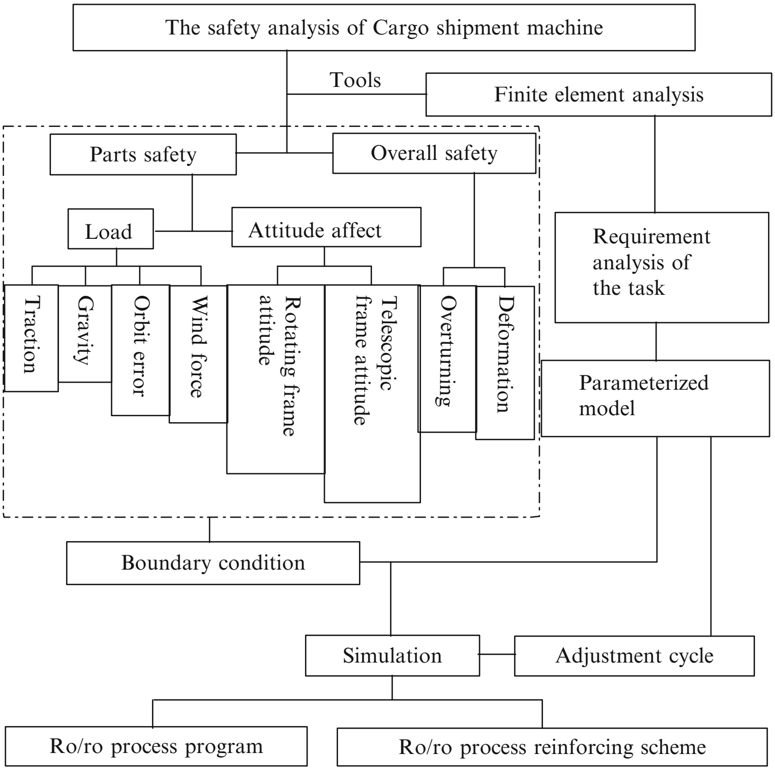

Fig. 2 The diagram of the Rolling safety analysis

stresses of parts decrease with the angle increasing. At the same time, the height of the gravity center increase rapidly with the angle of the boom system. Considering the above factors, the optimal angle of the boom system is $+7°$.

3.4.3 The Influence of Wind Load on the Safety of Rolling and Structure

The wind load is one of the most negative factors which will affect the balance of the shipping machines in the rolling process. The wind acting on the large scale equipment and other structures in engineering will form load because of its pressure. This approximate constant load will make the shipping machine capsize [14]. The ability against overturning of the shipping machine is defined as the stability of the shipping machine in the rolling process. In this process, when the algebraic addition of the stabilizing moments is greater than that of the overturning moments, the structure can be considered as stable. For the shipping machine, the stabilizing moment M_S, is generated by its gravity, while the overturning moment M_K, is generated by other loads such as wind load, dynamic load and vibration load, which is the force to rotate the shipping machine about a defined axis. The condition for the stability is $M_S > M_K$. However, in the actual working conditions, a margin for safety should be considered. Therefore, the factor of safety against overturning is introduced as $\gamma = M_S/M_K$ to ensure the safety of the shipping machine. From the relationship between the wind velocity and the factor against overturning, it is found that the factor against overturning decreases obviously with the increasing of wind. According to the Chinese standards used in engineering, the factor against overturning should be $\gamma > 4.0$. Most parts of the Shipping machine are flexible connections. Especially the boom system which is connected with other parts with hinge has a great wind area. As a result, the wind load will cause great influence on the structure. When the wind-force exceeds 8, the structure will has super linear increase with the increase of wind-force. The material of the shipping machine is Q345B steel whose yield strength is 345 MPa. When the safety factor is set to 1.5, the allowable stress is 230 MPa. According to the analysis results, the stress of the structure will approach to the allowable stress when the wind-force exceeds 10. In the actual case, considering the interference to the barge caused by shaking of waves, safety of rolling equipment, the security factors of the structure and ease of construction for workers, rolling process should be performed under the condition of no more than seven wind-force.

In summary, in the above case, the shipping machine is stable against overturning. Meanwhile, the impact of the wind on the structure security is within the safe range, and be of enough sufficient safety margin.

3.4.4 Safety Analysis of the Boom Maintenance Frame in the Rolling Process

The boom maintenance frame is installed bellow the fixed arm, its function is to adjust and maintain the boom frame system when necessary, and deliver the personnel and the equipments. In the rolling process, the boom maintenance frame is pulled forward with the main engine.

According to the static analysis results of the whole machine, the stress in the front section of the swing frame is greater under the effect of the gravity of the fixed arm and the telescopic arm. When designing the rolling plan, the fixed arm is constrained on the maintenance frame so that part of the gravity of the boom frame is shared to maintenance frame. Therefore, the influence of the boom frame gravity on the swing frame and the rotating frame column is reduced. Meanwhile, stability against overturning is also enhanced in the Z direction. In the simulation of the stress distribution of maintenance frame, parts with the maximum stresses are supporting position where the maintenance frame and the fixed arm are connected. The maximum stress is not only less than the allowable stress of the maintenance frame, but also has a sufficient safety margin. It is indicated that the maintenance frame structure is safe. In the rolling process, the attitude of the maintenance frame may present the following two cases.

First, the front wheels are driven onto the barge along the rails; at the same time, the rear wheels are still driving ashore. There is an altitude difference of the orbital plane between the shore side and the barge. From the analysis of the evolution of the maximum stress in the maintenance frame following the altitude difference, it is presented that the stress of the maintenance frame increases with the height difference., the maximum stress which is in the diagonal brace beam is in the middle of the connection frame when the altitude difference reaches 60 mm. The maximum stress approaches to the allowable stress as the altitude difference reaches 70 mm. As a result, the altitude difference must be strictly kept less than 70 mm.

Second, all the trolleys of the shipping machines are driven onto the barge, while the wheels of the maintenance frame are still ashore. Because the maintenance frame is a statically indeterminate structure, the wheels of the maintenance frame will be apart from the orbital plane and hanging in the air. At the moment, all the gravity of the maintenance will be imposed on the connection frame. In the contour plot of the stress, the part with maximum stress is still the diagonal brace beam which is in the middle of the connection frame. Furthermore, the maximum stress approaches the allowable stress. The simulation has shown that this plan cannot ensure the safety of the main engine. As a result, the rolling plan should be improved.

According to the simulation results, the improvement of the plans can be presented as follows. For the first plan, a group of pins which is used to connect the connection frame and the main engine can be released, so a rigid body rotational degree of freedom is released to decrease the deformation caused by the altitude difference. However, this plan will decrease the stiffness of the connection between the maintenance frame and the main engine. For the second plan, the wheels of the maintenance frame are removed before the rolling process. In this case, the bottom of the maintenance frame is free. This plan can avoid the deformation caused by the altitude difference because the maintenance frame just imposed by its gravity. In the simulations of the improved plans, the second plan makes the stress distribution more uniform. The maximum stress position of the maintenance frame is still in the diagonal brace beam in the middle. But the value of the maximum stress is much smaller than the allowable stress. It is indicated that the maintenance frame has the ability to afford its gravity. Therefore, the improved second plan is adopted in the rolling process.

3.4.5 Jacking Safety Analysis

The shipping machine should be constrained on the barge to increase the stability in transportation. When the complete machine of the shipping machine is pulled onto the barge, the machines should be jacking and rotated with the help of jacks prior to constrain.

Before constraining, the trolley is lifted to a certain height from the orbital plane. After being rotated 90°, the trolley is placed into the perpendicular fixed rails.

In order to ensure the stability and the safety of the parts such as the support column, the jacked height should be limited in a safe value, otherwise some parts of the machine may be destroyed.

When jacking the trolleys one by one, it is equivalent to the constraint with one degree of freedom, which is applied in the jacking point of the model. The relationship between the stress distribution and the jacking height can be obtained with the help of the simulation. According to the stress field from simulation, the maximum stress of the shipping machine occurs at the connection point between the corner of the gantry frame close to the jacking point and the support column. The relationship between the jacking height and structure stress shows that the maximum stress increases linearly with the jacking height. When the jacking height exceeds 80 mm, the maximum stress of the gantry frame approaches the allowable stress. Thus, the allowable height of jacking is limited to 60 to ensure the safety of the shipping machine.

3.4.6 Evaluation and Analysis of the Reinforce Plan in the Rolling Process

Based on the modal analysis of the complete machine, the mode of vibration can be use to research the vibration details of the complete machine when the machine is perturbed by the other loads in the rolling process. The weakest link in the rolling process can be found out with this method of evaluation which can supply the basis to the reinforce plan of the whole machine. In fact, the low order modes of vibration take main effect in rolling process. Therefore, the Blook Lanczos method is selected to extract the first 20 modes of vibration [15]. The modal analysis indicates that the frequencies of low order modes of the shipping machine are obviously greater than the frequencies of load variation in the pulling cables, as well as the frequency of the impact frequency caused by the trolley wheels through the rail joints. That is to say that there is not resonance in the rolling process. However, the impact frequency caused by the trolley wheels through the rail joints is very close to the low order frequencies. The combined effect caused by the multi loads will still induce small vibration on the lower stiffness of the boom frame system and the rotating frame. Thus, in order to ensure the safety in the rolling process, the weak parts need to be reinforced.

According to the simulation, the boom structure is a weak link. The fixed arm forepart can be connected with the gantry frame through associated constructions to limit the vibration. Meanwhile, the associated constructions can also be set between the rocking frame forepart and the rotating frame column as well as the rocking frame weight and the rotary rack tail weight to increase the stiffness of the structure. The cable between the rocking frame and the fixed arm is a slender rod which is easy to vibrate. Its stiffness can be enhanced by using a wire rope tied in the middle.

4 Discussion

The overall process and strengthening plan can be determined based on the four sub steps and the simulation of rolling process. The overall process is shown as follows: (1) the geometry of the Rotating frame structure is set to be symmetrical; (2) the optimal attitude of the boom frame system is $+7°$; (3) the rolling process of the shipping machine must be implemented when the wind fore is below 7; (4) the trolley of the maintenance frame should be removed when the machine is moving forward; (5) the jacking height of the trolley must be limited no more than 60 mm in jacking and rotation; (6) the fixed arm forepart can be connected with the gantry frame through associated constructions to limit the vibration; the associated constructions can also be set between the rocking frame forepart and the rotating frame column as well as the rocking frame weight and the rotary rack tail weight to increase the stiffness of the structure; The stiffness of the cable between the Rocking frame and the fixed arm can be enhanced by using a wire rope tied in the middle.

5 Conclusion

In this paper, The Standardized routing design of Project logistics based on the Process screening method is reported to improve the Project logistics technology of large scale equipments. With the help of the Computer Aided Engineering (CAE), Risk prediction and optimization and the design of the plan in the project logistics are realized.

1. Design ideas of project logistics standardization routing process based on the Screening method is introduced which is an improvement compared to the traditional engineering design method of logistics solutions based on the engineering experience.
2. Advanced CAE simulation technology is employed to implement risk prediction, evaluation and optimization in the project of logistics technology scheme, which makes the overall design plan more scientific and improves the efficacy and safety.
3. The overall scheme design is comprehensive systematically elaborated taking the rolling process of shipping machine for instance. It will make a positive significance in the research and practice of transportation of large scale equipments.

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Research on IOT-Based Material Delivery System of the Mixed-Model Assembly Workshop

Yun-long Wan, Hai-ping Zhu, Yan-ping Mu, and Hong-chen Yu

Abstract Taking a mixed-model assembly workshop as the research object, this paper proposes a material distribution method based on Internet of Things (IOT). Firstly, the material information of each assembly station is monitored in real time by using the IOT technology. Then, a model for the real-time material distribution in mixed-model assembly workshop is built. Aiming at the optimization of the vehicle routing problem, an improved genetic algorithm is designed to solve this model. Finally, the IOT-based material distribution system of mixed-model assembly workshop is developed on the basis of the previous researches.

Keywords Genetic algorithm • Internet of things • Material distribution • Mixed-model assembly • Vehicle routing problems

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1 Introduction

As the custom demand becomes diversified and personalized, the multi-varieties and small-batch production mode has become the main production mode of discrete manufacturing enterprises [1–3]. However, the production mode of multi-varieties and small-batch has caused a problem that the production material of workshop will increase dramatically. In order to guarantee the normal production, accurate and efficient distribution of material is particularly important. In the traditional assembly workshop, owing to the shortage of effective planning of material distribution route, an effective method to monitor the distribution of vehicles and obtain the material requirements real-time information of each assembly station, the material distribution often performs inaccurate and inefficient. Thence, the production line has to wait or even be interrupted, which delays the production schedule [4]. Thus, how to transport the demand material to the exact assembly station in the exact number at the exact time has become an urgent problem in the mixed-model assembly workshop [5–7].

Focusing on the mixed-model assembly workshop of Just in Time production environments, this paper proposes a material distribution method based by IOT. First of all, based on the exact layout of the mixed-model workshop, the material information of each assembly station is real-time monitored by IOT. Then, the real-time material distribution mathematic model of mixed-model assembly workshop is built. Aiming at the vehicle routing problems, an improved genetic algorithm is designed. Accordingly, based on the above, this paper puts forward an IOT-based material distribution system of mixed-model assembly workshop, and describes its structure and function in detail.

2 The Overall Scheme for the System

As shown in Fig. 1, the IOT-based material distribution system is divided into four modules: smart scheduling module, material control module, ZigBee route management, data acquisition system. The previous two subsystems form the material distribution system, and the latter two subsystems constitute the wireless sensor networks of the mixed-model assembly workshop [8–10].

2.1 The Hardware Design of Nodes

As a short-range, low-power wireless communication technology, ZigBee technology has a close, low-complexity, self-organizing, low-power, low data rate, low cost and other characteristics [11–13]. ZigBee technology can be easily embedded in a variety of devices, which makes the wireless communication device work at low

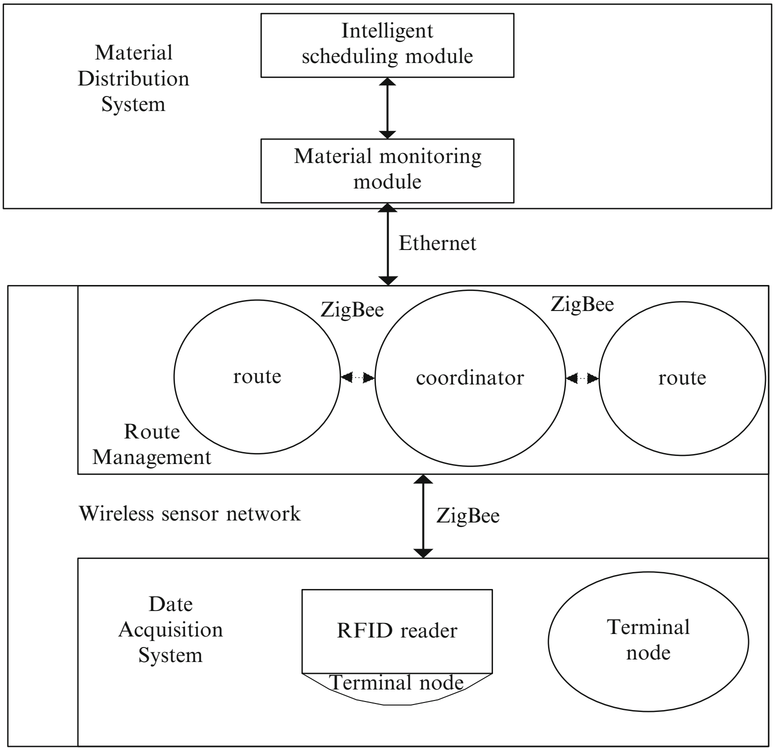


Fig. 1 Structure of the material distribution system

power consumption and cost [14]. ZigBee network consists of three types of nodes: coordinator node, routing node and terminal node.

2.1.1 ZigBee Coordinator Node

The coordinator node is the core of the workshop wireless sensor network, responsible for the establishment of a network, management, maintenance, completion of the data collection and forwarding. The coordinator node includes micro-processing module, RF module, serial-to-Ethernet module, human-machine interaction module, FLASH memory module, power module etc. Figure 2 shows the block diagram of the coordinator node.

2.1.2 ZigBee Route Node

The route node realizes routing functions, including: receiving and forwarding the data, ensuring the quality of communications link, relaying data transmission,

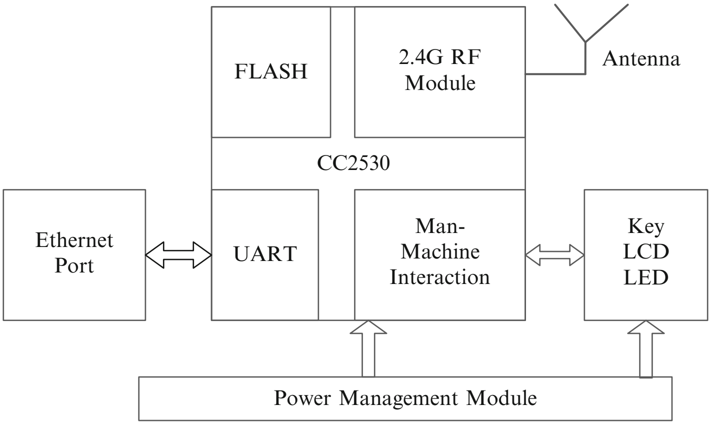
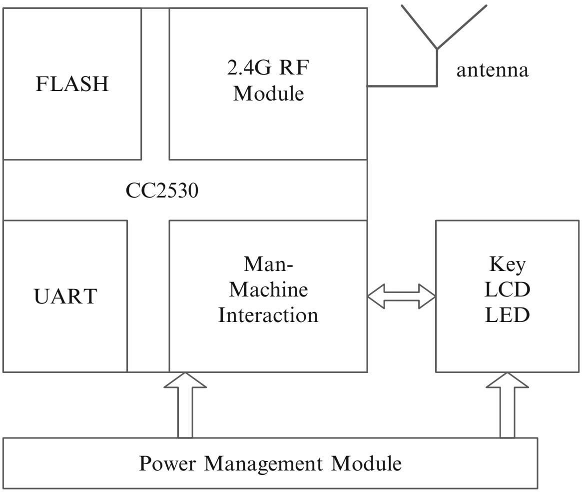


Fig. 2 Block diagram of the coordinator node

Fig. 3 Block diagram of the route node



expanding the coverage of wireless sensor networks. Route node mainly consists of micro-processing module, RF module, serial module, human-machine interaction modules, FLASH memory module, power supply module. The block diagram of the route node is shown in Fig. 3.

2.1.3 ZigBee Terminal Node

The terminal node acts as "tentacles" in wireless sensor network, providing initial raw data for the entire system. In the data acquisition system, the terminal node collects products and materials information through RFID tag reader. Similar to the route node, the block diagram of the terminal node is shown in Fig. 4.

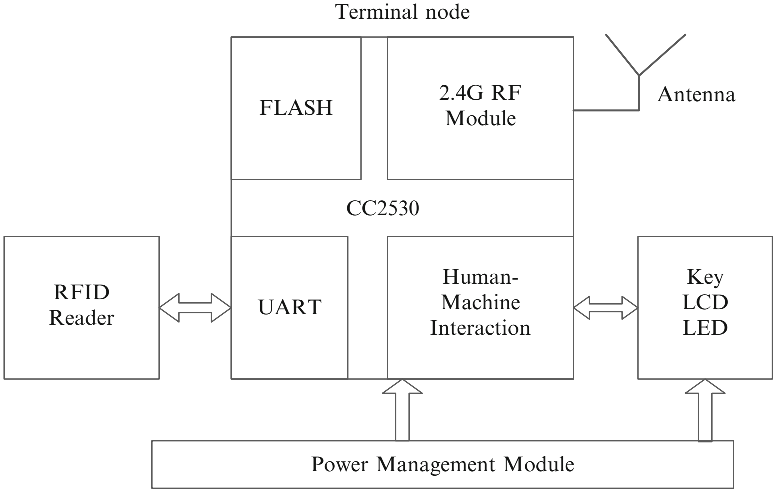


Fig. 4 Block diagram of the terminal node

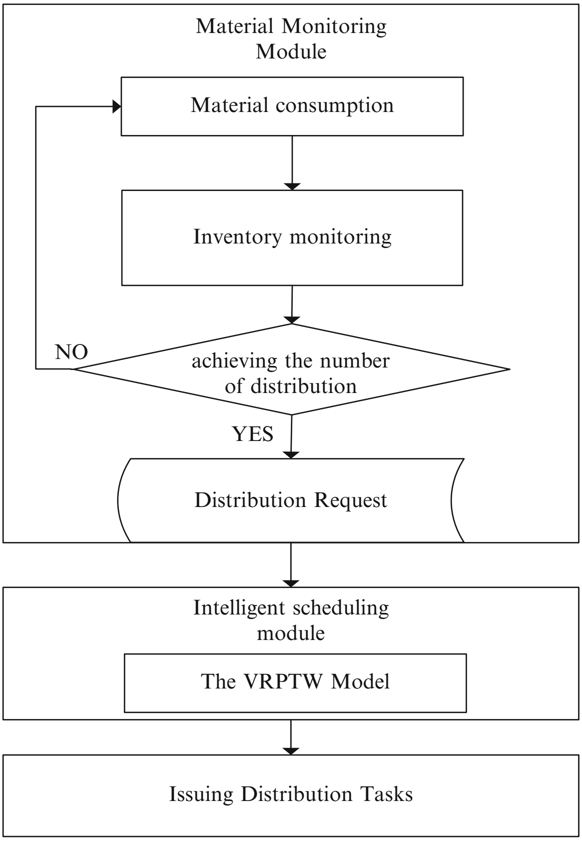
2.2 *The Design of Material Distribution System*

Material delivery system consists of two modules: material monitoring module and intelligent scheduling module. Through wireless sensor networks in mixed-model assembly workshop, material monitoring module records the real-time material information from different assembly stations. Intelligent scheduling module extracts material demand information from the distribution demand sent by the material monitoring module, and processes this information by using intelligent optimization algorithm and then generates efficient material distribution scheme. Figure 5 shows the detailed process of material distribution system.

2.2.1 Material Monitoring Module

According to the characteristics of the material, the system will be divided into real-time distribution of materials (JIT pieces and cache pieces) and non-real-time distribution of materials (standard parts) [15]. For these two kinds of materials, operating principle of material monitoring module is different. The former one is monitored automatically and the latter one is monitored manually. When the production line is lacking of the real-time materials, the material monitoring module sends the line side with the information of the work in process and bill of material, and calculates the types and quantities of the demanded material. However, when the production line is short of non-real-time materials, the material monitoring module gets the information about the types and quantities of demand material via human-machine interaction module of terminal nodes.

Fig. 5 The process of material distribution system



Real-time distribution of materials is distributed according to the production line tact and the materials demands. Material demand, material consumption, line side inventory and plan assignments, the system calculates the types and quantity of the logistics required for each station. According to the material demand, material consumption, line side inventory and the amount of scheduled tasks, the system calculates the type and quantity of the logistics required for each station.

Detailed process is as follows:

1. Determining the type and quantity of materials consumed by the production line

Each station is equipped with an RFID tag reader, and each of the work in process is tied an RFID tag. When the products go through stations, RFID tag readers automatically read RFID tags of the products. Then, the number of the products assembled at a certain station is accurately calculated. Thus, according to the bill of material, the material monitoring module can determine the type and quantity of consumed materials.

2. Issuing distribution requests, when the inventory line side is lower than the safety stock

According to the number of products, getting from the readers, the material monitoring module calculates the line side inventory. When the inventory is below the safety stock, distribution request is issued, which contains the type and quantity of materials, stations of the production line, delivery time and other information.

The shortage problem of the non-real-time materials could be solved by material call. Due to the number of uncertainty, the standard parts cannot be real-time distributed. When the production line is short of non-real-time materials, the standard parts can be replenished by material call. When a station of the production line lacks of non-real-time materials, assembly workers sent distribution request via human-machine interaction module of terminal nodes, which contains the type and quantity of materials, stations of the production line, delivery time and other information.

The materials used in the assembly production process are divided into real-time distribution of materials, non-real-time distribution of materials. Regardless of the types of materials, with the combination of real-time delivery pattern and non-real-time call pattern, system can replenish materials timely in order to guarantee the normal production.

2.2.2 Intelligent Scheduling Module

Intelligent scheduling module extracts material demand information from the distribution demand sent by the material monitoring module, optimizes the distribution vehicle routing by using intelligent algorithm and finally generates an efficient material distribution scheme. The following describes the process of establishing and solving the mathematical model.

In generally, the schedule model of material distribution can be described as the vehicle routing problem with time windows, (Vehicle Routing Problems with Time Window, CVRPTW), the mathematical model of which is defined as follows [16]:

The warehouse of distribution center has some identical vehicles used to serve n stations (V_1,V_2,$\cdots$,V_n), it is know that the vehicle capacity is Q, and the fixed cost of vehicle dispatching is $h \geq 0$. The demand of V_i station is q_i, and $q_i < Q$. It is required that the range of time when the task begins to be performed is [a_i,b_i], the serve time of the task is s_i. c_{ij} and t_{ij} represent the cost and the travel time associated with section (v_i,v_j) respectively. The requirements of the problem is designing the traveling route of vehicles so that each task begin to execute within the predetermined time, the task of each station is executed only once within a planning cycle (That is, each station is visited only once), and the cost of vehicle dispatching should be the least.

Variables assumption:

If the designed route has used the section of (v_i,v_j), then $x_{ij} = 1$, otherwise $x_{ij} = 0$; x_{0j} means sections from the distribution center to the station

p_i is the time that the vehicle arrives the station v_i
y_i is the deadweight that the vehicle lefts the station v_i

At the information-determined case, the mathematical model is as follows:

$$\min \sum_{j=1}^{n} h x_{0j} + \sum_{i=0}^{n} \sum_{j=0}^{n} c_{ij} x_{ij} \tag{1}$$

S.T.

$$\sum_{j=0}^{n} x_{ij} = 1, \quad i = 1, \ldots, n \tag{2}$$

$$\sum_{i=0}^{n} x_{ij} = 1, \quad j = 1, \ldots, n \tag{3}$$

$$if \;\; x_{ij} = 1 \;\; then$$

$$y_i - q_j \le y_j \tag{4}$$

$$q_j \le y_j \le Q \;\; i = 1, \ldots, n \tag{5}$$

$$p_i + s_i + t_{ij} \le b_j \tag{6}$$

$$p_i + s_i + t_{ij} \ge a_j \tag{7}$$

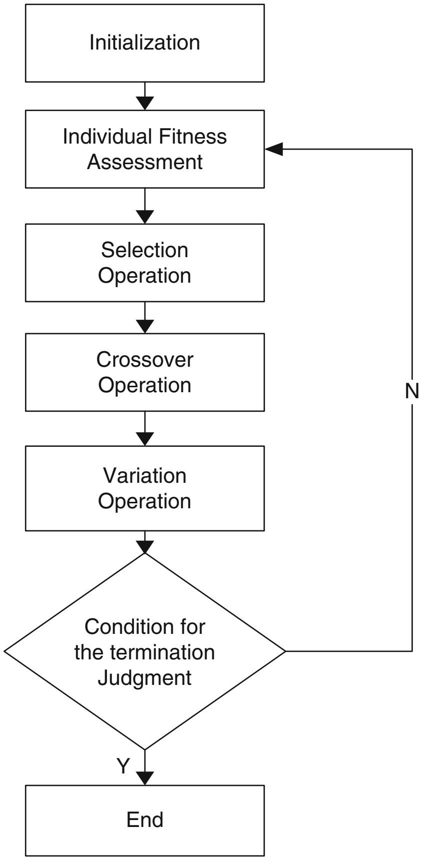
$$a_i \le p_i \le b_i \tag{8}$$

$$x_{ij} \in \{0, 1\} \tag{9}$$

The description of mathematical model:

The constraint condition of formulas (2) and (3) ensures that each station is just assigned in one route, that is, each station can be visited only once by a car, it is only a car departure from the station. Formulas (4) and (5) are the capacity constraints of a car, which express that before reaching the station, the vehicle must be able to provide services to the station, and formulas (6), (7) and (8) ensure to meet the need of station about time window constraints. Formula (9) is the range of self-variable.

Fig. 6 Operation process



In the objective function (1), to achieve the minimum distribution cost, the total cost of vehicle dispatching and trips is minimized.

Figure 6 shows the fundamental operation process of genetic algorithm.

Initialization includes chromosome coding, parameter setting and populations generating. Fitness reflects chromosome pros and cons. Selection reflects the natural law of the survival of the fittest. Crossover embodies the idea of sexual reproduction. Variation reflects the idea of the evolutionary process of gene mutation. The condition for the termination judgment is the number of iterations.

3 Application of Material Distribution System

Taking the mixed-model assembly workshop of an automobile manufacturing enterprise as example, this paper verifies the feasibility and effectiveness of the material distribution system on the basis of the previous researches.

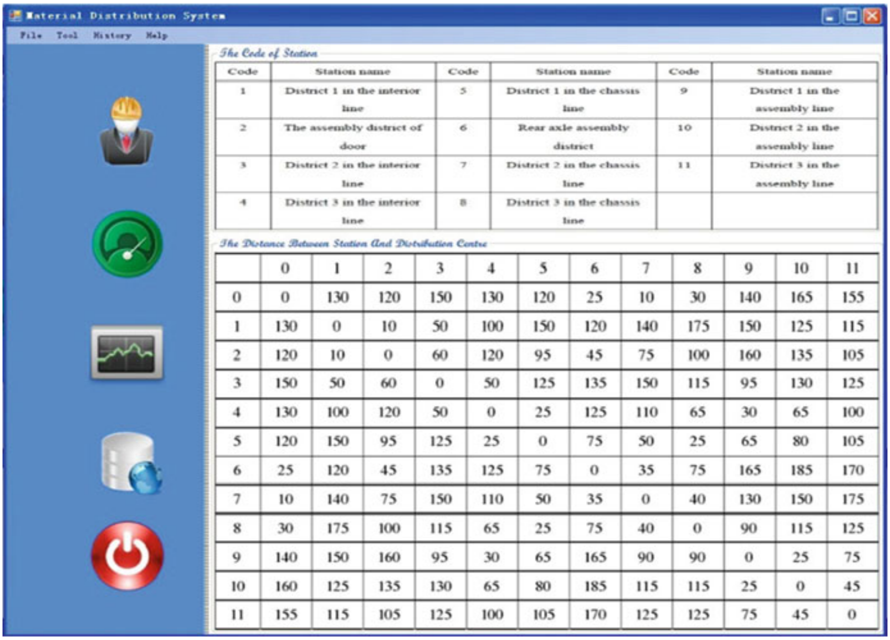


Fig. 7 Basic data

The interface of the system is as shown follows.
The descriptions of the system operation process:

1. Basic data acquisition
   The assembly workshop can be divided into 11 material distribution stations, and the distance from the distribution center to each station has been calculated. Figure 7 shows the code of stations and the distance list.
2. Material monitoring
   By using the IOT technology, the material inventory of each station is real-time monitored. Thus, the system can obtain the real-time information about the types and quantities of demand material. Figure 8 shows the monitoring scene and the distribution demand sequence.
3. Intelligent scheduling
   Intelligent scheduling module extracts the basic data and material demand information from system, and optimizes the distribution vehicle routing with intelligent algorithm. Figure 9 shows the parameter setting of genetic algorithm and the results of optimization.

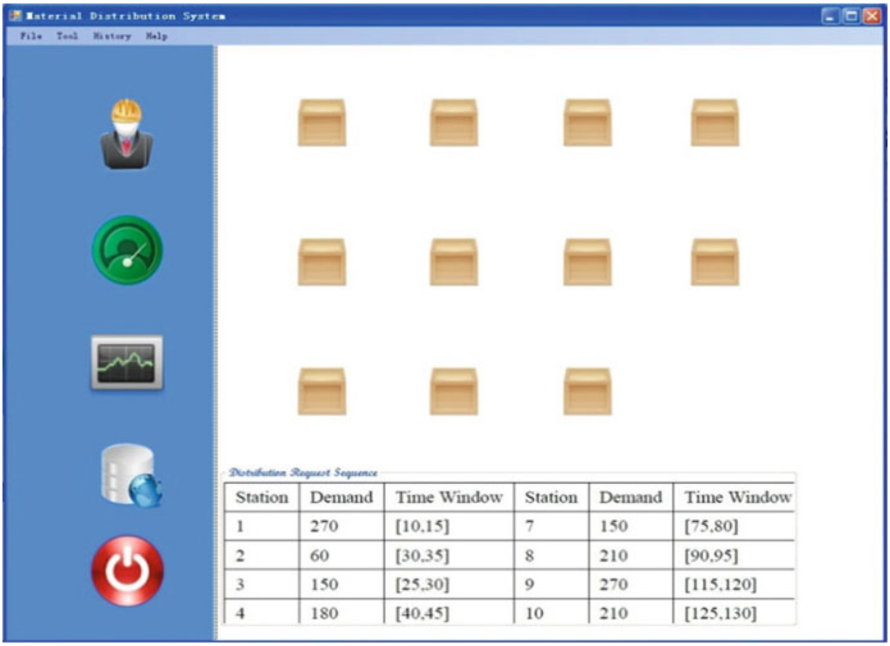


Fig. 8 Material monitoring

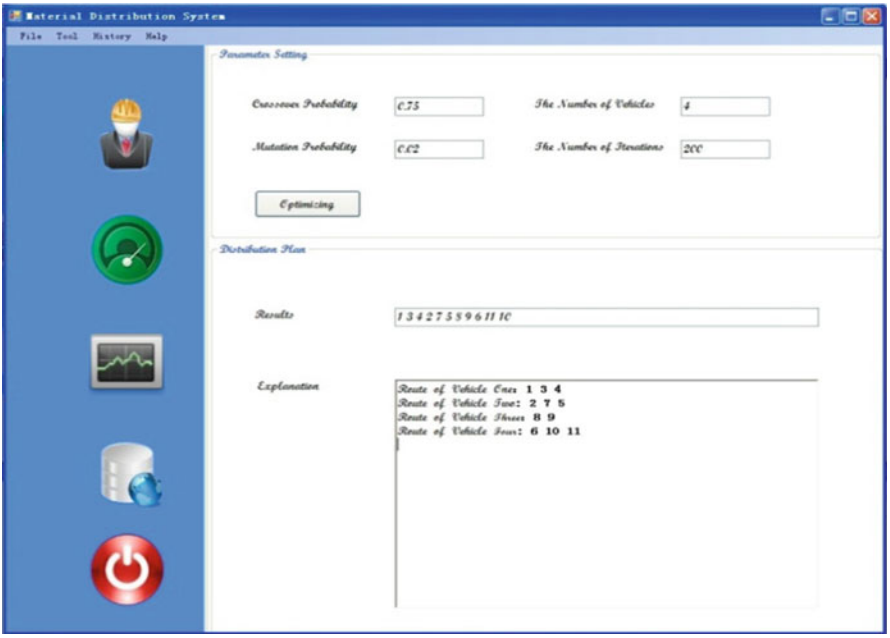


Fig. 9 Results of optimization

4 Conclusion

Aiming at the mixed-model assembly workshop of Just in Time production environments, this paper proposes a method of material distribution based on IOT, and develops a prototype of system. Combining the layout information of the mixed-model assembly workshop and the materials information of each assembly station which is real-time monitored with the Internet of Things technology, the real-time material distribution mathematic model of mixed-model assembly workshop is built. Solving this model by using the intelligent optimization algorithm, system generates a material distribution plan.

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The Self-Organized Criticality of Customer System

Xiao-guang Luo

Abstract The purpose of this paper is to explore the evolution law of crowd behavior of customers under the effect of Word-of-Mouth (WOM) by theoretical analysis on the nature of customer system and the effect of WOM. The integration of customers of a business unit is defined as customer system with the individual customer as sub-unit and the nature of the system is discussed. Then, the two dimensional cellular automation (CA) model is built and five experiment schemes are designed to simulate the aggregate crowd behavior of the customer group. The results generated from the research were quantitatively analyzed based on the concept of Self-Organized Criticality (SOC).

Keywords Crowd behavior of customers • Customer system • Cellular automation (CA) • Self-Organized Criticality (SOC) • Word-of-Mouth (WOM)

1 Introduction

Studies have explored that the cost to acquiring new customers is significantly higher than retaining existing customers ones [1]. An increase in customer retention will bring higher revenues and reduce the marketing cost [2], so the customer retention strategy has stimulated significant interest among academics and practitioners since the 80th of twenty centuries with more and more intensive competitive in the market [3].

Most of this researching is focusing the individual customer level [4]; however, the crowd behavior of the combination of total customers of a business organization is also worth to noticing. A customer's purchasing behavior could be influenced

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greatly by other customers [5]. One customer's buying may trigger many other's buying decision, and the dissatisfaction of one customer could induce the refusal of repurchase of many others, and vice versa [6]. With the customer word-of-mouth (WOM) as the main media of the interaction of customer group, the customer group will generate large-scale and collective visible behavior [7, 8].

Defining the combination of total customers of a business organization as a customer system with the individual customer as the subcomponents, it could be proved that the system is an adaptive complex system and the crowd behavior of customer group could be very complex [9]. Even though only a few research haves been published, the research of the crowd behavior of customer group in using the modern complexity theory is triggered [10]. In this paper, the evolution mechanism of the customer system is simulated by the cellular automation model (CA) to analyze the aggregate crowd behavior of the customer group. The main object is to assess the probability of the avalanche of customer system, and the great scale of churn of customer, due to the spread of negative WOM in hoping to make reference to the decision of customer retention.

2 Methodology

In this study, the integration of customers of a business unit is defined as customer system with the individual customer as subunit. The structure of customer system will evaluate constantly along its life cycle for the interaction of information and energy with the environment that is composed by micro elements such as the marketing activities of enterprises, etc., and macro elements such as economy, culture, politics, technology, etc. The two aspects evaluating customer system are noticeable, which are the scale of the system and the interrelation of the subunits in the system. Based on the product life cycle theory, the hypotheses could be made that the scale of the customer system at the introduction stage might be quite small and the connections among the subunits are not active; the scale of the system will increase from the introduction stage to growth stage and will get to maximum at maturity stage that may reach to millions or even more, and also the connections among the subunits will be reaching to the most active level.

Each customer in the customer system has his or her "game rule", the standards of evaluation on product and the methods of decision on purchasing. Customers will make their purchasing decision independently based on the "game rule", with no decision concerning the whole system and the collection of individual customer decision integrated to the mass behavior of the system. Although the purchasing decision is made by the customer himself, the decision is influenced by the interaction among the subunits of the customer system mainly with the means of WOM. The effects of the influence of other people on the decision making could not be reflected in a liner function or even deterministic function; a customer defiantly will take the opinion, word and behaviors of other customers as reference when making his decision [11].

To simulate the customer system, the two dimensional cellular automation model is designed. It is postulated that all customers of a business unit is distributed in a rectangular lattice domain with cells defined as an individual customer, where n represents the scale of customer system. The state of cell (PS_i) is determined by the dissatisfaction degree formed by the purchasing experiment of a customer in a finite number from 0 to 3, the bigger the number is, and the more unsatisfactory the customer's feeling is.

Set the ξ_1 as the threshold value that a customer exits the customer system, that is when the $PS_i \geq \xi_1$, the customer i will exit the system by refusing to repurchase the product of the enterprises, or in other word, this cell is landslip. Also it is set at this state; the cell will diffuse the dissatisfied feeling to its m_1 neighbor cells by means of WOM, and cause these cells change to new state by adding one more unit of dissatisfaction than the original one. Sometimes even the customer's dissatisfaction degree is not high enough to drive him or her exiting the system; he or she may spread the negative WOM to reduce his or her anxiety or to prevent others from the bad experience that they had encountered [12]. Than ξ_2 is set as the threshold value that the customer will spread negative WOM to others, that is when the $PS_i \geq \xi_2$, the customer i will diffuse the dissatisfied feeling to its m_2 numbers of neighbor cells. The m_1 and m_2 could be decided by the closeness of information contact among the subunits in the customer system.

The initial state of cells in the CA could be decided by regulation set according to the need. Then put one state value randomly to a cell, simulating one customer becomes more dissatisfied caused by the flaw of marketing of enterprises, the evaluation of the system could be observed. In the real world, just one customer's exit will not influence the pattern of information contact among the subunits in the customer system, so it is designed that if one cell landslips, the position of the cell is replaced by another customer, and the state of the cell is set by the regulation mentioned above. Then the rule of evaluation of cells in the model is decided by the following formulation:

$$PS_i^{t+1} = \begin{cases} Rand \text{ ...... } PS_i = PS_i^b \\ PS_t^t + \nabla PS_t^t \text{ ...... } PS_\mathrm{i} = PS_i^{tr} \\ PS_t^t \text{ ...... } PS_i = PS_i^u \end{cases} \quad (1)$$

PS_i^{t+1}:	The state of cell i before time $t + 1$
PS_i^t:	The state of cell i before time t
Rand:	The state set by the regulation
PS_i:	The evaluation state of cell i in time t
PS_i^b:	Cell i is landslip in time t
PS_i^{tr}:	The state of cell i changed in time t
PS_i^u:	The state of cell i fixed in time t
∇PS_i^t:	The value added to cell i in time t

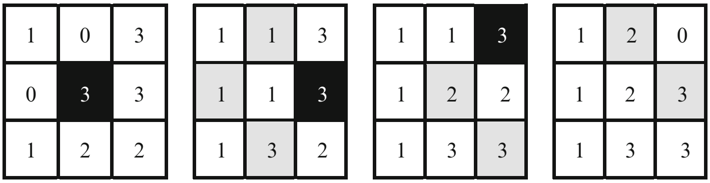

Fig. 1 The avalanche process in customer system column

In this model, suggesting a dissatisfaction value is added randomly to a cell and set the ξ_1 is 3, m_1 is 4, if the state of the cell that accept the dissatisfaction value is less than 3, then there is no other change in the system; if the state of cell is equal or bigger than 3, the cell will crash and it will transmit one dissatisfaction value to its 4 neighbor cells. The cells accepting the dissatisfaction value may crash also, and cause other cell crashing continually (Fig. 1).

The concept of Self-Organized Criticality (SOC) is introduced by Bak, Tang and Wiesenfeld to describe the behavior of complex system. SOC theory states that adaptive complex system with large numbers of components will evolve into a "critical state" spontaneously where a minor event may cause very weak response or an avalanche of all size of scale. Unlike in chaotic state, a system in a critical state exhibits long range spatio-temporal correlations with power law: the probability of occurrence of an event is inversely proportional to its size [13, 14].

If process from the first cell crashing to the end of chain reaction be defined as an avalanche. Recording the number of cell crashed in an avalanche as s, and the frequency of avalanche in scale s as f, if the customer system is in the criticality state, the f and s must follow the power law distribution according to the SOC theory, that is:

$$f = cs^d \tag{2}$$

The c and d are constant number, or in the logarithmic form:

$$\log(f) = \log(c) + d\log(s) \tag{3}$$

The parameters of experiments based on the customer system cellular automation model designed are set out as follows:

Named PCT_1, PCT_2, PCT_3 and PCT_4 denote the percentage of state of cell to be 0, 1, 2 and 3 on the total cells in the system in sequence and then set at the initial state PCT_1, PCT_2, PCT_3 and PCT_4 equal to 30 %, 30 %, 30 % and 10 % in sequence. The scale of customer system is set as 10,000, or in other word set n = 100. And ξ_1 and ξ_2 are set as 3 and 2 separately.

With the difference in m_1, five experiment schemes are designed:

Experiment scheme 1 (ES1): $m_1 = 1$, and $m_2 = 1$;
Experiment scheme 2 (ES2): $m_1 = 2$, and $m_2 = 1$;

Experiment scheme 3 (ES3): $m_1 = 3$, and $m_2 = 1$;
Experiment scheme 4 (ES4): $m_1 = 4$, and $m_2 = 1$;
Experiment scheme 5 (ES5): m_1 equal to the random integer from 1 to 4, and $m_2 = 1$.

The first four experiment schemes are designed to stimulate the degree of connection of information contact among the subunits in the customer system from low to high; and the fifth experiment scheme simulates the atypism situation of the degree of connection information contact among the subunits. For each experiment scheme, 50 thousands dissatisfaction value are input to the system one by one.

3 Findings and Discussion

To simplify if the number of collapsed cell after inputting a dissatisfaction value is from 1 to 500, then the scale of an avalanche is recorded as 500, if the number is from 501 to 1,000, recorded as 1,000, and so on. For the number over 10,000, it is just recorded as over 10,000. The frequency that occurred for different scale of avalanche is calculated (Table 1).

Generally, along with the input of the dissatisfaction value to the customer system continually, the PCT_1, PCT_2, PCT_3 and PCT_4 will change ceaselessly and PCT_1, and PCT_2 will show decreasing trends. Meanwhile PCT_3 and PCT_4 will show increasing trends. Since it is set that if one cell collapsed, the state of the cell is set by the regulation set before, then if an enormous avalanche (the scale is near or even over 10,000) occurred, the PCT_1, PCT_2, PCT_3 and PCT_4 will resume to its initial state, so the PCT_i changes in an irregular periodic pattern. The initial, minimum and maximum value of PCT_i for five experiments is recorded in Table 2.

The data of experiment scheme 1–4 presents that there had existed a tendency of polarization for the fluctuation of customer system, the effect of dissatisfaction value will cause very small avalanche or catastrophe and that the scale of avalanche is near or even over 10,000. The more closeness of information contact among the subunits in the customer system, the higher possibility of great avalanche in the system emerges. When m1 is equal to 1, there are only three times of avalanche that the scale is near or over 10,000, when m1 is equal to 2, this number increase to 5; when m1 increases to 3, there are 225 times of great avalanche, and when m1 is up to 4, this number increase to 1,221. However, any regularity of scale of avalanche and the occurred frequency could not be found in these four experiment schemes.

Unlike the other four, the data of experiment scheme 5 presents that the scale of avalanche is distributed from small (500) to huge (more than 10,000), and the frequency of the scale occurring decline with the increase of the scale. The scatter plot in rectangular coordinate system with *log (f)* as ordinate axis and *log(s)* as abscissa axis present the linearity pattern with negative slop (Fig. 2). The linear regression in using the log(s) as independent variable and *log(f)* as dependent variable confirm the linear relationship between the *log(f)* and *log(s)* of experiment scheme 5 with coefficients(d) equal to -1.686, R^2 equal to 0.84, significant level equal to 0.000 and Durbin-Watson equal to1.366.

Table 1 Scale and frequency of avalanche

Scale of avalanche	Frequency for ES1	Frequency for ES2	Frequency for ES3	Frequency for ES4	Frequency for ES5
500	12,848	11,237	5,070	4,081	8,572
1,000	0	0	0	0	186
1,500	0	0	0	0	109
2,000	0	0	0	0	71
2,500	0	0	0	0	54
3,000	0	0	0	0	51
3,500	0	0	0	0	38
4,000	0	0	0	0	41
4,500	0	0	0	0	18
5,000	0	0	0	0	19
5,500	0	0	0	0	29
6,000	0	0	0	0	27
6,500	0	0	0	0	17
7,000	0	0	0	0	16
7,500	0	0	0	0	18
8,000	0	0	0	0	15
8,500	0	0	0	0	17
9,000	0	0	0	0	8
9,500	0	0	0	0	15
10,000	2	1	5	3	15
The frequency of cell not collapsed	37,149	38,758	44,705	44,698	40,351
The frequency of cell collapsed over 10,000	1	4	220	1, 218	313

Table 2 The change of number of PCT

		Experiment scheme				
	PCT_i	ES1	ES2	ES3	ES4	ES5
Initial value of PCT_i	PCT_1	29.57	29.52	29.84	30.03	29.83
	PCT_2	30.05	30.45	30.19	30.09	30.01
	PCT_3	30.46	30.31	29.69	29.26	29.85
	PCT_4	9.92	9.72	10.28	10.62	10.31
Minimum value of PCT_i	PCT_1	8.71	7.58	25.58	27.93	8.73
	PCT_2	20.77	20.99	28.12	28.46	20.98
	PCT_3	29.97	29.15	28.70	28.75	28.58
	PCT_4	9.63	9.67	9.43	9.00	9.80
Maximum value of PCT_i	PCT_1	30.56	30.29	30.98	31.50	31.13
	PCT_2	30.45	30.95	31.44	32.20	31.28
	PCT_3	35.43	36.07	31.67	31.71	35.45
	PCT_4	36.23	36.15	13.58	11.60	35.89

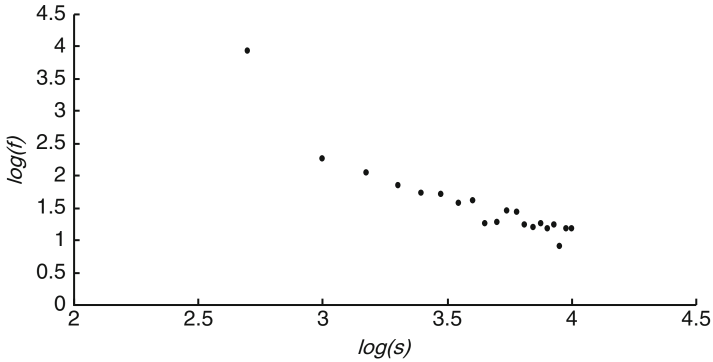

Fig. 2 Scatter plot of log (f) and log (s) of experiment scheme 5

4 Conclusion and Managerial Implications

The purpose of this research is to explain how the crowd behavior of the combination of total customers of a business organization is likely to be when the native WOM happens. Specifically, it draws on whether the customer system will evaluate to the criticality state the effect of WOM on the market of a business unit.

The simulation based on the cellular automation model of customer system shows that the customer system will evaluate to criticality state when the degree of connection of the subunits in the system is nonuniform. The study on the WOM network has proved that generally the degree of connection of the subunits in the system is nonuniform in real world [15], so marketers should aware that a negative WOM may cause only little fluctuation in system as well as an avalanche through whole system that result in bankruptcy of business. Preventing the initiation of negative WOM and restricting the diffusion of these is very important and effective means to manage the crowd behavior of customers.

Comparing the result of experiment schemes 1–4, it is clear that the degree of connection of the subunits in the system is one of the most important factors deciding whether the customer system will crash under the effecting of negative WOM. If 50 % of customers' existing in the system be defined as the collapse of customer system, then in $m1 = 1$, the possibility of system crash is only 0.006 %; when it is $m1 = 4$, the possibility is as high as 2.442 % that is 406 times of when $m1 = 1$. Actually, the possibility of collapse of system is exponential growth for m1 (Fig. 3). In the view of traditional concept of WOM, the degree of connection of the subunits in the system is not high and there is less possibility that the subunits in the system are fully connected [16]. But, with the development of modern media on interpersonal communication such as internet, the degree of connection could reach a very high level, especially, in the later part of growth stage and the maturity stage

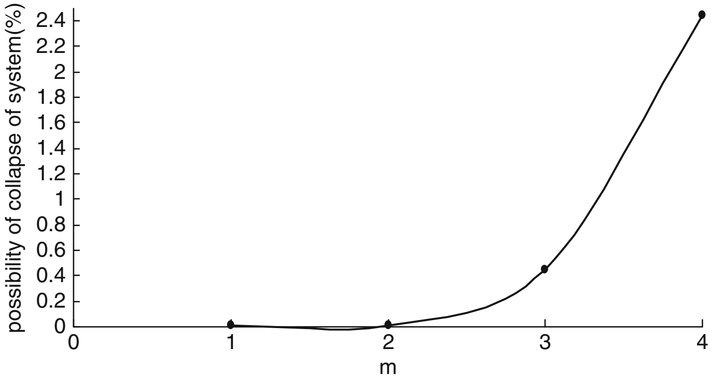

Fig. 3 The increase of possibility of collapse of system

of product life cycle, and the negative WOM will spread much faster and wider than before. This could explain why many very successful enterprises suddenly lost their market and even go bankruptcy at the period of full bloom.

Coherent with many previous studies, this research reveals the importance of customer satisfaction. In all experiment schemes, adherent with the increasing of dissatisfaction degree, the possibility of big avalanche is increasing when one more dissatisfactory value is added. To illustrate the relationship between the dissatisfaction degree and the possibility of big avalanche, first a variable *WAUS* is defined to reflect the weighted average dissatisfactory value in the system, then:

$$WAUS = (PCT_1 * 0 + PCT_2 * 1 + PCT_3 * 2 + PCT_4 * 3)/100 \quad (4)$$

In experiment schemes 5, the minimum, maximum and mean of *WAUS* are 1.179, 1.964 and 1.489 in sequence. Then the dissatisfaction degree of system is grouped to three levels: low ($1.179 \leq \text{WAUS} < 1.489$), medium ($1.489 \leq \text{WAUS} < 1.691$ (the 75 % of the range)) and high ($1.691 \leq \text{WAUS} \leq 1.964$). Also the scale of avalanche is classified to smaller group (the number of collapsed cell is less than 5,000) and great group (the number of collapsed cell is over 5,000). The crosstab analysis shows that most great avalanche occurred when the dissatisfaction degree of system is at high level. Pearson Chi-Square test shows the Pearson Chi-Square = 834.092, and $p = 0.000$, that means the difference of great avalanche occurrence in three dissatisfaction degree levels is statistically valid. The conclusion of likelihood Ratio test is coherent with Chi-Square test. The correlation of great avalanche and dissatisfaction degree levels is proved by Symmetric Measure, the Spearman Correlation is 0.122 with $p = 0.000$. The marketers should noticed that the average of satisfaction (dissatisfaction) level in the customer system is an accumulating phenomenon, so they should make effort continually to promote satisfaction, as well as to reduce dissatisfaction.

5 Limitations and Future Research

In this research, only the influence of negative WOM is considered in exploring the evolvement of the customer system. In real word, the positive and negative WOM may happen alternately; the evolvement of the system could be more complex.

The pattern of WOM spreading in customer system is quite complicated. There are many subgroups with diversity of scale and the degree of connection. Individual customer could be classified to different roles according to the function they operated in spreading WOM, such as the opinion leader that connects with others and have more power to influence others, linker of subgroups that promote the diffusion of WOM among the different subgroups, the active WOM spreader who is enthusiastic to spread the WOM but may not influence others attitude and active WOM seeker who has the enthusiasm to search the WOM to help their decision, etc. The CA model of customer system designed in this research did not concern the complex phenomenon fully.

Many research opportunities exist to broaden and deepen on the concept of evolution of the customer system. Considering the positive and negative WOM simultaneously will help marketers to understand the rule of evolution of the customer system more accurately. Also, to ensure the subunit of the model of customer system with more complicated behavior rule on transmitting WOM and reacting to it based on the conclusion of WOM study and customer behavior will improve the authenticity on simulating the crowd behavior of customers.

Research based on the concept of customer system, in applying SWORM model, could be undertaken to simulate the crowd behavior of customers to predict the customer churn, discover the boundary condition when the customer system at robust, SOC and chaos, also find the robust structure of customer system.

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Research on CRM System of Manufacture Techno-service Enterprise

Ru-hong Ma, Xiao-hui Dong, and Da-zhi Jiang

Abstract This article discusses the manufacturing technology services companies in its customer relationship management needs and characteristics of a technology-based market value of three-dimensional model of customer value theory, put forward a multi-project, multi-target project management process and achieve the development of a CRM System, use of customer value segments of customers, maximize the profit increase customer life cycle, the effective management of the project process, to achieve internal and external knowledge sharing.

Keywords CRM • Client value • Knowledge manage • Project process manage • Manufacturing technology service

1 Introduction

CRM is developed based on the relationship marketing and Business Process Reengineering (BPR). And a new marketing concept of customer-centric is its core concept. Foreign studies have shown that the cost of developing a new customer is five times higher than it of retaining an old customer [1]. Ph.D. Don Peppers and Martha Rogers once pointed out: “If the enterprise customer churn rate can be reduced by 5 %, there will be a growth of 100 % profit.” The practice has proved that only traditional experience and practices have been very difficult to work in developing and enhancing brand loyalty. Therefore, customer relationship management (CRM) became the force of leading trend of global economics.

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CRM projects are heavily introduced in both representatives of the new economy and traditional enterprises to redesign products and to reconstruct organizational processes. It has become the core value of the enterprises [2].

2 CRM Project Features of Manufacturing Technology Service Enterprise (MTSE)

A very typical characteristic of MTSE is to provide a complete set of technical solutions or improving program for each customer, which must be a unique personalized item. Just like other projects, it is needed to plan, coordinate and use a variety of resources reasonably at a given time. There are four points for the demand of project management [3, 4].

1. To think systematically, to arrange practically and globally;
2. To provide the exact basis for the project of human resources needs;
3. To optimally control the project through reasonable plan arrangements;
4. To provide accurate, consistent, standard document data.

According to these needs upon, CRM system for MTSE should be project-oriented, to form a multi-project, multi-index three-dimensional. In the system, project is for the vertical axis, which is run through personnel management, rights management, contract management, schedule management, work plan, assigning work management and document management. The entire corporate clients and business management can be achieved ultimately.

3 Requirements for System Functionality and Performance

3.1 The Main Function Demanded [3]

1. Track and record for the project
   It must be managed that the whole process of project introduce and contact, program design and study, contract management, project implement, and products sales. During it, the information and data of meeting discussion, technical documentation, contracts, and principal person will be recorded, so that the staff can be convenient, fast and comprehensive understanding of the progress of the project and detailed information. As result, collaborative office can be achieved;
2. Management for customers, contacts and information
   The task is to manage basic customer information, the contacts information, marketing activities, customer evaluation and etc., including creation, query and maintenance of the file of customers and contacts. Moreover, record,

maintenance, query of the data of co-loaders and competitor information can also be accomplishing. To know both ourselves and our adversaries in the market competition, effective coping strategies can be made.

3. Due to the interview assessment indicators and outreach staff not familiar with the problems of business and technology, the knowledge management module of Service Q & A Knowledge Base, interview questions is developed through the idea of knowledge management,;
4. Support and service for customer
   It must be managed and intuitive analyzed that the day-to-day customer service activities and tasks, such as customer feedback and complaints.
5. System function
   The system function mainly includes rights management, data query, reporting printing, bulk mail, chart analysis, system settings, as well as some commonly used software tools called.

3.2 Performance Requirements

1. Good operability: friendly man-machine interface, operation is simple and convenient;
2. High reliability: the system should be stable and reliable operation, possessing the functions of error handling;
3. Scalability: The system should be modular, and can be cut and extended;
4. Higher running speed;
5. Good economy: The system should be advanced and practical, and easy to maintain;

4 System Design

4.1 System Front Design

The C/S technical structure model is adapted in the system designing. The C/S is also known as Client/Server or client/server mode, which uses a high-performance PC, workstation or minicomputer for its server, and possessing large-scale database systems such as ORACLE, SYBASE, or the SQL Server. The develop software for client-side is Delphi 7.0.

The principles for system design are to grasp the diversification and personalization characteristics of customers; to response to customers demand as rapid as possible; to attract new customers and retain old customers. The system is designed to improve the relationship between businesses and their customers, and to establish a new operation mechanism. The system takes overall customer

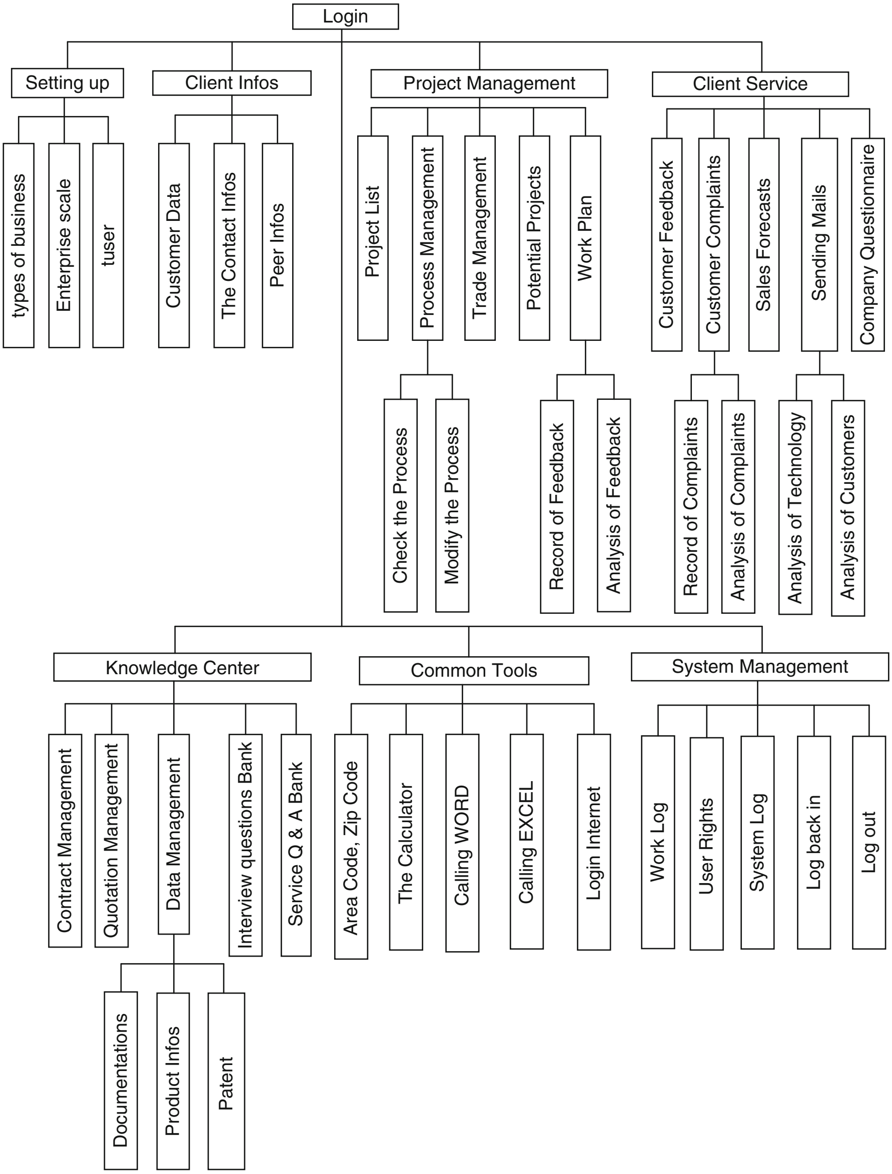

Fig. 1 The system functional module

management of enterprise-class as solutions, which help enterprises to establish unified customer resources, to standardize enterprise project process, to establish the learning-oriented knowledge management system, and to maximize customer value ultimately [5]. The system functional module is shown as in Fig. 1.

4.2 Database Design

According to the needs analysis and database design principles, an independent concept model of specific database management system through synthesizing, inducing and abstracting the user needs [6]. Then the conceptual model is converted to the relational model. The data model diagram of the system is established on the basis of relational integrity and standardization requirements.

4.3 System Code

Encoding rules of the system for customers, contacts, system log, customer feedback, and project are unified [7]. Having unified coding, repeated entries can be avoided. There are several encoding principles below.

Uniqueness: coding cannot be repeated, and the same encoding can only represent a transaction. Uniqueness encoding is the fundamental principles of the encoding.
Versatility: The code structure should be simple, clear and less digits (generally not more than 20). It is needn't to embody all transaction information on coding;
Usability: easy to use, easy to remember;
Scalability: cannot be modified after the coding once identified, it must be considered to facilitate expansion and cause chaos in the expanded;
Efficiency: suitable for computer processing, suitable for rapid entry appropriate to identify, so that the coding is not needed to design too long.

Based on the above principles, the structure of the coding system is divided into three parts: the type (3 bits), creating time (8 bits) and quantity (4 bits), which the total length of them is 15. In the system, coding is produced automatically by using a stored procedure. The following is a code example of a section of the stored procedure.

```
CREATE PROCEDURE getClientID @outClientID varchar(20)
out AS
DECLARE @Number varchar(20),@Count varchar(4),@Title
varchar(8)
set @Title = 'CLI'
set @Number = year(getdate())  /*getdate()*/
if month(getdate()) < 10
   set Number = @Number + '0' + convert(varchar(5),
month(getdate()))
else
   set @Number = @Number + convert(varchar(5),
month(getdate()))
if day(getdate()) < 10
```

```
   set @Number = @Number + '0' + convert(varchar (5),
day(getdate()))
else
   set @Number = @Number + convert(varchar (5),
day(getdate()))
set @Count = '0001'
while exists(select * from tb_client_information where
client_id = (@Title + @Number + @Count))
begin
set @Count = @Count + 1
   if @Count < 10
      set @Count = '000' + @Count
   else if @Count < 100
      set @Count = '00' + @Count
      else if @Count < 1000
              set @Count = '0' + @Count
end
set @outClientID = @Title + @Number + @Count
GO
```

4.4 Project Process Management Module

The system file architecture of project process management module is shown in Fig. 2.

During the system design, it is required to follow the guiding ideology of setting multiple projects in parallel and paying equal attention to multi-index, Through fully understanding the project from several aspects, it will be easy to track enterprise project progress, to make appropriate working arrangements and plan, and to achieve engineering project management [8]. The main idea is to set project as the center, to manage each project synthetically such as the stages of progress, the technical documentation, pictures documents, records of meetings, contracts, expense management, as well as potential project records and work plan.

4.5 Knowledge Management Module

In the Knowledge management module of the system, a knowledge center has been designed according to the actual needs of enterprises and fully communications with enterprise managers [9, 10]. It includes five core functions of contract management, quotation management, data management, interview questions and quiz library.

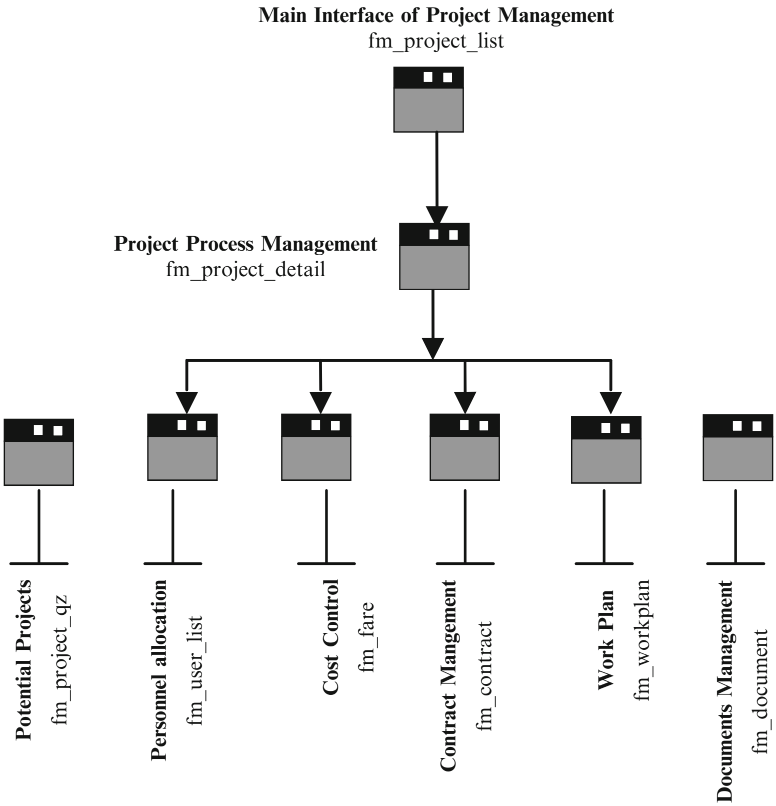

Fig. 2 The system files structure of project process management module

By building product information base, MTSE itself will have many series of products based on the technology innovation, and achieve unifying management for product information in CRM.

4.6 *Customer Service Module*

The customer service module mainly includes customer feedback, typing-in and analysis of customer complaints, the message sending, and the management of the company questionnaire [11, 12]. Through the unified record of customer feedback and complaints, customer satisfaction can be tracked and written down, then overall customer satisfaction can be seen through the intuitive way of chart. Customer feedback and analysis is shown in Fig. 3.

Fig. 3 Customer feedback and analysis

5 Conclusion

1. With the rapid development of web technology, system development of B/S architecture model is growing popularity. In this structure, the user interface is achieved through www browser, which a very small part of the business logic is fulfilled in the front-end (Browser), but the main transaction logic is completed on the server side (Server). As a result the so-called three-tier 3-tier structure is formatted. This greatly simplifies the client computer loads, reduces the cost and workload of system maintenance and upgrade, and at last lower the overall costs (TCO). This system can be developed into the B/S architecture on the basis of the existing functional modules;
2. Due to lack of uniform standards within the company, offering price mainly according to human experience and without the support of scientific algorithms, quotation executive is needed to further study
3. Analysis and decision-making functions can be added after the data volume of operability CRM reaching a certain amount, and it is needed to further study about data mining [13–15].

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An Empirical Research on the Effects of Ingredient Brand Equity on Consumer's Brand Evaluation

Yan-qun Zheng and Meng-ju Shi

Abstract More and more enterprises adopt the ingredient brand combination strategy; they hope with the help of the good image of ingredient brand to enhance their brand value. In this paper, through empirical study I found that ingredient brand equity does influence the level of consumers' evaluation of the main brand; through further analysis, I believe that when consumers think over the component brand equity, they will be affected by their own product knowledge and involvement on the subject.

Keywords Brand alliance • Brand equity • Brand evaluation • Ingredient brand

1 Introduction

In order to increase the products difference and improve consumers' evaluation of brand; more and more enterprises adopt brand combination strategy. Ingredient brand is the important sources of product quality; the key property of a brand is the main component of another brand. For example, Dell using the Intel CPU in their computer; by the components' good image, ingredient brand combination strategy can enhance the main brand's value and competitiveness. Now the academic research is just in its infancy; therefore, this paper attempts to discuss whether the consumers will be affected by their own product knowledge and involvement when they consider component brand equity to evaluate the main products.

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2 Methodology

2.1 Theory and Research Hypothesis

2.1.1 Brand Alliance

Scholars research on Co-branding problem using different methods which derived various definitions. Keller (2002) thinks the brand alliance is more than two brands united into a combined product or market together [1]. Cooke and Ryan (2000) believe brand alliance is one form of strategy alliance, which links or integrates the attributes of more than two brands to provide new or improvement products [2]. Park et al. (1996) consider it combines existing brand names to create composite brand name [3]. I suggest that two brands' advantage united to provide the combined benefits and strengthen the difference by the ingredient brand attributes, which also has the brand alliance function.

2.1.2 Ingredient Brand

Ingredient brand is the special case of brand alliance; an essential component in the product has its own brand. Keller (2002) considers the ingredient brand creates brand equity for the components and parts materials included in brand products [1], such as Intel chip. So the ingredient brand is the key attribute of a brand being combined as the main component of another brand. This paper mainly discusses whether the components brand equity will affect consumer brand evaluation of the main products; not to explore the interaction of the main products brand and the ingredient brand, which is the limitation of the study.

2.1.3 Brand Equity

Aaker (1991) defined brand equity as a group of assets and liabilities connected with the brand, brand name and symbol, which may increase or decrease the product's (or service's) value. Brand equity originates from brand loyalty, brand awareness, perceived quality, brand association and other exclusive brand asset [4]. Keller (1993) considers the brand equity is from the brand awareness which can be described by brand awareness and brand image [5]. Other scholars mainly define brand equity from financial or marketing perspective.

Cobb-Walgren et al. (1995) investigated the impact effect of brand equity on consumers' preferences and purchase intention, with brand awareness, brand association and perceived quality measuring brand equity; they found the higher of the advertising budget, and the higher of brand equity, consumers have higher brand preference and purchase intention [6]. On the basis of these results, I measure the component brand equity by brand awareness, brand loyalty and perceived quality, and then deduce which has a positive effect on brand evaluation.

Hypothesis 1: when ingredient brand equity is higher, it can more enhance consumers' brand evaluation on the main product.

2.1.4 The Consumer Involvement

Involvement refers to "a person perceives the association with the object based on inherent needs, values and interests." When the "association" is measured, it is called involvement. Petty et al. (1983) using ELM (Elaboration Likelihood Model) model found that, in the high involvement conditions, the correlation between the brand attitude and purchase intention was significantly higher than lower involvement situation [7]. Yuetian Lin (1996) found that with the higher degree of product involvement, consumer will have better brand recognition [8]. The high-involvement consumers will carefully evaluate the buying program and extensively search for information; they will fully consider the impact of components brand equity on the main brand.

Hypothesis 2: The higher the degree of consumer involvement, ingredient brand equity will more affect consumers' brand evaluation on main products.

2.1.5 The Product Knowledge

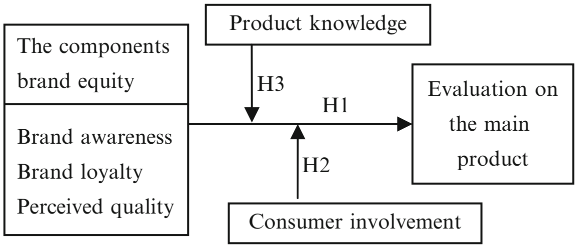
Alab and Hutchinson (1987) thought that the product knowledge is mainly composed of specialized expertise and product familiarity [9]. Park and Lessig (1981) divided familiarity into three kinds of degree; when product familiarity increases, consumers will know more product attributes and develop different knowledge profiles to evaluate it. With high product knowledge consumers use external attributes to build products knowledge profile and further inference to the quality of the products [10].

Hypothesis 3: With more product knowledge, components brand equity will more influence consumer's evaluation of the main product.

2.1.6 Brand Evaluation

Brand evaluation refers to the degree of consumer's brand preferences [5]. Aaker (1996) thought brand evaluation included consumer attitudes, perceived value and purchase intention [11]. Perceived value is trade-off between perceived benefits and perceived loss when consumers have the purchase intention [12]. I measure consumers' evaluation of the main brand by their perceived value.

Fig. 1 Conceptual model



In addition, whether ingredient brand can be sold independently and the exclusive contract will have a moderating effect on the relationship. But for the limited space, I will not study. Based on the discussion, I propose the following conceptual model as shown in Fig. 1.

2.2 *Research and Design*

2.2.1 Sample Data

Computer penetration rate is quite high in college, but in different grades and majors, students' involvement and product knowledge are different. On the other hand the core component of the computer is the central processor; consumers may take care of the central processor's brand. Intel is the market leader, and most computers are marked with "Intel Inside" logo. I select Lenovo Y series and E series as the research product, because Y series has Intel processor, Lenovo E series has other brand; other configurations are exactly the same. The sample is the university students in Wuhan city; I used the cross control quota sampling respectively with the School of management, Institute of foreign languages and the computer department as a hierarchical index, and grade as another control. With the self-administered questionnaire by online survey, respondents are asked according to their actual consumption.

I investigated 550 questionnaires, 538 being recovered, so the recovery rate is 97.82 %. The effective questionnaires are 527, and the pass rate is 97.96 %. The sample's cultural statistics is shown in Table 1.

2.2.2 Scale Design

To ensure the validity of the questionnaire, the table comes mainly from the predecessors. Measurement of consumer evaluation on the main product is 5 problems, from Zeithaml [13]. Consumer product knowledge has 3 problems from Smith and Park [14]. Consumer involvement has 5 problems according to Biying Ni [15]. Consumer evaluation of brand equity is 14 problems from the view of Aaker [11].

Table 1 The personal information of effective questionnaires

Gender	Male		Female	
	38.7 %		61.3 %	
Department	School of management	Institute of foreign languages	Computer department	
	36.4 %	31.1 %	32.4 %	
Grade	Freshman	Sophomore	Junior	Senior
	15.9 %	28.3 %	29.8 %	26 %
Whether having computer	Yes		No	
	90.9 %		9.1 %	

Table 2 Reliability analysis of the latent variables

Latent variable	The amount of measurable variables	Cronbach's Alpha
Product knowledge	3	0.748
Consumer involvement	5	0.802
Competent brand equity	14	0.868
Evaluation on the main product	5	0.805

Cronbach's Alpha is 0.875, indicating that the whole questionnaire has good reliability. To test the reliability of each latent variable, the results are shown in Table 2. For validity analysis, KMO = 0.853, P (Bartlett test) = 0.000, so the validity of the questionnaire is good.

3 Results

3.1 The Overall Effect of Components Brand Equity on the Main Brand Evaluation

Using AMOS7.0 to construct the SEM (Structural equation model), the statistical results show that $\chi^2 = 98.921$, the degree of freedom is 85, and NC = 1.164 ranged from 1 to 3, $p = 0.143 > 0.05$, indicating the model can well fit the sample data. $TLI = 0.961 > 0.95$, $CFI = 0.958 > 0.9$, $IFI = 0.961 > 0.9$, $RMSEA = 0.05 < 0.06$, ECVI and AIC values of the assuming model were less than the independent and saturated model value. All the indicators have reached the standard, so the model can be accepted. SEM is verified shown in Fig. 2.

The path coefficient of the components brand equity's impact on the main brand evaluation is 0.41, and CR = 7.206; P = 0.000, so hypothesis H1 is supported.

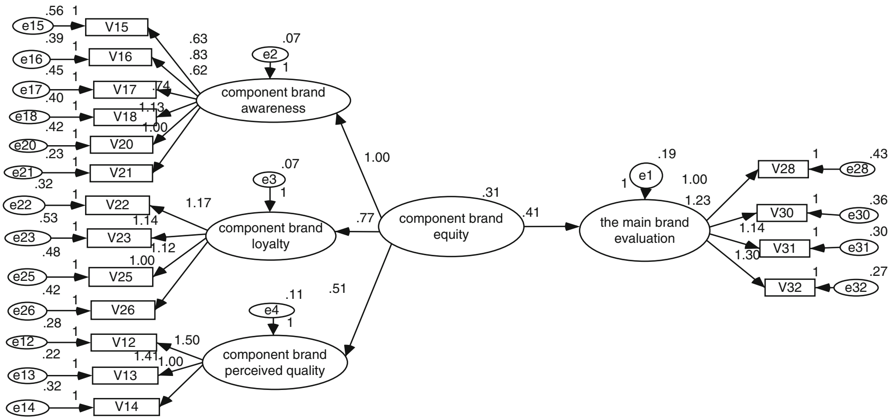


Fig. 2 AMOS fitting SEM

Table 3 Analysis of the effects of involvement

Involvement	Relationship among the constructs	Path co-efficient	C.R.	p	Testing results
Low	Component brand equity	0.255	2.1	0.0	H2 is supported
	$\longrightarrow$		82	29	
High	The main brand evaluation	0.441	6.0	0.0	
			87	00	

3.2 *Interference Analysis of Consumer Involvement*

I add up the 5 items score to obtain the average indicating the involvement level; then I use single factor variance analysis. $P = 0.03 < 0.05$, it proves the students' (from three departments) product involvement is significantly different.

I divided the samples into to groups by the average with 1 indicating the low involvement less than three, 2 as the high-involvement more than three. I make two SEM of components brand equity impact on the main brand evaluation respectively using the two groups, statistical results shown in Table 3.

Constructing the SEM with low involvement consumer samples, $NC = 2.229$, ranged from 1 to 3, $p = 0.063 > 0.05$, so the model can fit the sample data. $TLI = 0.965 > 0.95$, $CFI = 0.908 > 0.9$, $IFI = 0.909 > 0.9$, $RMSEA = 0.057 < 0.06$, ECVI and AIC values of the assuming model were less than the independent and saturated model value. All the indicators have reached the standard, so the model can be accepted.

Constructing the SEM with high-involvement consumer samples, $NC = 2.166$ ranged from 1 to 3, $p = 0.065 > 0.05$, so the model can fit the sample data.

Table 4 Analysis of the effects of consumers' product knowledge

Product knowledge	Relationship among the constructs	Path co-efficient	C.R.	p	Testing results
Low	Component brand equity →	0.355	6.257	0.000	H3 is supported
High	The main brand evaluation	0.602	3.793	0.000	

TLI = 0.968 > 0.95, CFI = 0.92 > 0.9, IFI = 0.921 > 0.9, RMSEA = 0.047 < 0.06, ECVI and AIC values of the assuming model were less than the independent and saturated model value. All the indicators have reached the standard, so the model can be accepted.

3.3 *Interference Analysis of Consumer Product Knowledge*

I add up the 3 items score to obtain the average indicating the consumer product knowledge level; then I use single factor variance analysis; the results show that the product knowledge of students from three colleges is not significantly different, but the students from different grades have significant differences in product knowledge, (P = 0.016 < 0.05).

I divided the samples into to groups by the average with 1 indicating low product knowledge less than three, 2 as the high-involvement more than three. I make two SEM of components brand equity impact on the main brand evaluation respectively using the data of low product knowledge and high product knowledge consumers, statistical results shown in Table 4.

Constructing the SEM with low product knowledge consumers samples, NC = 2.903, ranged from 1 to 3, p = 0.057 > 0.05, so the model can fit the sample data. TLI = 0.953 > 0.95, CFI = 0.918 > 0.9, IFI = 0.919 > 0.9, RMSEA = 0.051 < 0.06, ECVI and AIC values of the assuming model were less than the independent and saturated model value. All the indicators have reached the standard, so the model can be accepted.

Constructing the SEM with high product knowledge consumers samples, NC = 2.367 ranged from 1 to 3, p = 0.052 > 0.05, so the model can fit the sample data. TLI = 0.958 > 0.95, CFI = 0.938 > 0.9, IFI = 0.944 > 0.9, RMSEA = 0.049 < 0.06, ECVI and AIC values of the assuming model were less than the independent and saturated model value. All the indicators have reached the standard, so the model can be accepted.

According to the results of SEM, the research hypothesis is supported shown in Table 5.

Table 5 Hypothesis testing results

Hypothesis	Content	Testing results
H1	When ingredient brand equity is higher, it can more enhance consumers' brand evaluation on the main product	Supported
H2	The higher the degree of consumer involvement, ingredient brand equity will more affect consumers' brand evaluation on main products	Supported
H3	With more product knowledge, components brand equity will more influence consumer's evaluation of the main product	Supported

4 Conclusion

The empirical study finds that high component brand equity enhances the consumers' brand evaluation of the main product, and with the increase of consumer's product knowledge and involvement, the influence becomes greater. That is to say, consumers with more product knowledge are more susceptible when they evaluate the main product brand thinking over components brand equity, because the understanding of products. The consumer with higher product involvement will take the initiative to collect information related with product; they are more inclined to consider the components brand equity's impact on the main products.

The study confirmed the important position of components brand in the main products, Company implementing brand strategy can bring the reciprocity. To improve the competitive position, the enterprises providing intermediate products or raw materials should adopt the customer-oriented brand strategy, and establish unique component brand recognition, such as Intel. It let a lot of personal computer buyers only buy the computer with "Intel" logo. In results, the main personal computer makers Dell, Compaq and IBM buy chip of higher prices from Intel and never from the unknown suppliers having the same chip. Similarly, when selecting suppliers, the enterprises producing final products should choose ingredients with high brand equity in order to enhance the consumers' brand evaluation of the final product and improve the competitiveness.

But this study only take the computer as the example, if the research can have the control group, the conclusion will have more reference value. I select college students as sample, so the conclusion can only represent the 18–25 old age level, which cannot be deduced to other age groups. So I suggest for future research to select component brand with different popularity for comparing to see the different effect of the components brand and to expand the scope of sample of different ages.

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Green Supply Chain Coordination – A Game Theoretic Approach

Yun Huang and Kuifun Ip

Abstract This paper considers the problem of coordinating price, remanufacturing, and configuration decisions in a green supply chain with one manufacturer and multiple suppliers. The manufacturer purchases optional components of certain functionality from his alternative suppliers to produce a set of products to meet the requirements of different markets. Suppliers can procure a quantity of used components, and then remanufacture them or order new materials from external suppliers to serve as inputs of the components. The authors model this problem as a Stackelberg game in which the manufacturer, as a leader, is aware of the optimal decision reactions of his suppliers and can consider these reactions to maximize his own profit. The analytical method and genetic algorithm are utilized to determine the equilibrium of the game. Finally, a numerical example is presented to understand the influence of different parameters on the decisions and profits of the supply chain and its members.

Keywords Green supply chain • Pricing • Remanufacturing • Stackelberg game

1 Introduction

Green supply chain management is defined as integrating environmental concerns into the inter-organizational practices of supply chain management, including reverse logistics [1]. Many product categories, from car batteries to printer cartridges, can be made new through remanufacturing [2]. Firmsengaging in green

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supply chain management experience many environment and financial benefits from remanufacturing. Any major greening activity requires efforts from the entire supply chain [3].

Green supply chain management has become a new research paradigm in operations management [4–6]. Zhang et al. [7] provide a comprehensive review of green design and show that "environmentally conscious design and manufacturing" results in safer and cleaner factories, worker production, improved product quality at lower cost, higher productivity, and so on. Srivastava [8] comprehensively reviews a broad frame of literature of green supply chain. These studies on green supply chain management focus on the descriptive or behavioral aspects, and do not employ analytical modeling. Remanufacturing is an industrial process in which used products are repurposed for useful purposes [9]. Many researchers also study how products can be designed to facilitate the remanufacturing process. Shu and Flowers [10] argue that, if a product (or its parts) is not intended to be reused, adapting a product for disassembly, cleaning, or reassembly is meaningless. Bras and Hammond [11] develop a design for remanufacturing metrics and apply it to several product case studies.

A growing number of research papers use game theory to model remanufacturing decisions. Savaskan et al. [12] consider how an appropriate reverse channel structure is chosen for the collection of used products from customers. They model different collection options as decentralized decision-making systems with the manufacturer being the Stackelberg leader. Ghosh and Shah [13] examine the influence of channel structures on greening levels, prices, and profits using game models, and propose a two-part tariff contract to coordinate the green channel. Swami and Shah [14] coordinate a manufacturer and a retailer in a vertical supply chain in which both players put in efforts for "greening" their operations and the manufacturer acts as a Stackelberg leader. In the above research, price and level of green innovation/reverse channel performance are the major factors studied in the reverse channel or green supply chain. In addition, these studies only consider the channel with single manufacturer and single retailer.

This paper incorporates reuse and remanufacturing into product family planning in a green supply chain with multiple suppliers and a single manufacturer. The Stackelberg game model is proposed and applied in this paper to study how negotiation between players in a green supply chain affects their decisions. In this paper, the manufacturer, as a leader, can know the optimal decision processes/reactions of his suppliers, and considers such reactions to maximize his own profit. The suppliers, as followers, try to maximize their profits with their autonomies. The authors propose analytical and genetic algorithm (GA) methods to obtain the equilibrium in this game.

This paper is structured as follows. Section 2 presents the problem description and assumptions. Section 3 proposes the mathematical model and the analytical and computational methods used to solve the model. In Sect. 4, a numerical example and a sensitivity analysis on market potential parameter and maximum cost savings from remanufacturing are presented. Finally, Sect. 5 presents our conclusions, and some limitations and suggestions for further work are discussed.

2 Problem Description and Assumptions

The authors consider a two-echelon green supply chain involving a single manufacturer and multiple suppliers. The manufacturer, indicated as m, designs and customizes a set of platform products for different independent market segments (indicated as l, $l = 1, 2, \ldots, L$). Each market segment is served by a product customized from the product platform. The architecture for the product platform consists of a series of internal interfaces. For each interface, a number of product components with similar functionalities but different levels of performance or features are grouped together. The components within an interface can be ranked in order of decreasing functionality, in which components with higher functionality can completely replace ones with lower functionality, but not vice versa. Thus, for the manufacturer, component selection is based on whether higher-functionality components should be selected to replace lower-functionality ones fixed a priori. The authors define the set of components in an interface performing similar functionality as a substitutable component set (SCS). All components are purchased from a fixed number of alternative suppliers (v, $v = 1, 2, \ldots, V$). The authors suppose that the suppliers incorporate a remanufacturing process for used components into their original production system, so that each supplier can either directly produce a new component from raw materials or remanufacture part or whole of a returned unit into a new one.

The authors suppose I SCSs and N_i components for the ith SCS ($i = 1, 2, \ldots, I$). Here, L_{ij} is used to denote the component, which is the jth element in the ith SCS, where $i = 1, 2, \ldots, I$ and $j = 1, 2, \ldots, N_i$; the vth supplier offers a bidding price p_{vij} of the jth component in the ith SCS to the manufacturer; and c_{vij} is the unit cost of producing a new component L_{ij}. If the vth supplier does not supply the component L_{ij}, the cost of manufacturing this component (i.e., c_{vij}) is set as a large positive number.

Let r_{vij} be the maximum amount of cost savings that the supplier v can attain using a used component to produce a new component L_{ij}. Similar to [15], component innovation requires upfront investment in remanufacturing, which is provided by the supplier. In defining ρ_{vij} as the fraction of this maximum cost reduction that results from an investment from the supplier v, ρ_{vij} is assumed to be a single value for the same component. The upfront investment in innovation provided by each supplier for the component, which is quadratic in nature, is $\psi_{vij}\rho_{vij}{}^2$, where ψ_{vij} is the positive constant [16]. Thus, by investing $\psi_{vij}\rho_{vij}{}^2$, the supplier v can reduce his marginal cost by $r_{vij}\rho_{vij}$. This cost structure can be found in the literature [16].

The manufacturer and the suppliers are assumed to be rational decision makers. The manufacturer is inferred to have the dominant market power. An immediate question facing the manufacturer is how to determine wholesale prices and suppliers, as well as the component selection decisions that will maximize his net profit. The problem of the supplier focuses on the component price and the fraction of the maximum cost reduction for each component. A Stackelberg game is played between the suppliers and the manufacturer. In this game, the manufacturer makes his first move on pricing, whereas the suppliers and components selection decisions are based on the reaction functions of the suppliers. The suppliers determine their bidding prices and remanufacturing decision (i.e., the fraction of maximum amount of cost saving) based on the manufacturer's decisions.

3 Model

To facilitate the modeling, some other parameters and decision variables are used:

a_l: base market potential of market segment l
b_l: sensitivity of demand to price changes of product l
c_l: production cost per unit product l
u_{ijl}: predefined usage amount of unit component L_{ij} per unit product l
g_v: fixed cost of using supplier v, covering supplier certification, contract setup, etc.
Ω_v: number of different types of components supplier v is capable of supplying
q_l: demand of market segment l
p_{vij}:price of component L_{ij} supplied by supplier v
τ_{ijk}: binary decision variable to indicate whether component L_{ij} is used to replace L_{ik}
ξ_v: binary decision variable to indicate whether supplier v is used
t_{vij}: binary decision variable to indicate whether component L_{ij} is supplied by supplier v
z_{ij}: binary decision variable to indicate whether component L_{ij} is used
w_l: wholesale price set by manufacturer for product l
π_m: profit of the manufacturer
π_v: profit of supplier v

The manufacturer takes on the cost of components, production cost, and cost associated with adopting suppliers, such as negotiation, contract signing, and so on. The following profit function is considered for the manufacturer:

$$\text{Max } \pi_m = \sum_{l=1}^{L} w_l q_l - \sum_{l=1}^{L}\sum_{v=1}^{V}\sum_{i=1}^{I}\sum_{j=1}^{N_i} p_{vij} z_{ij} \left(u_{ijl} + \sum_{k=j+1}^{N_i} u_{ikl}\tau_{ijk} \right) t_{vij} q_l - \sum_{l=1}^{L} c_l q_l - \sum_{v=1}^{V} g_v \xi_v \tag{1}$$

s.t.

$$q_l = a_l - b_l w_l \tag{2}$$

$$\sum_{j=1}^{k-1} \tau_{ijk} + z_{ik} = 1, \forall i = 1, 2, \ldots, I; \;\; j = 1, 2, \ldots, N_i - 1; \;\; k = j+1, \ldots, N_i, \tag{3}$$

$$\tau_{ijk} \le z_{ij}, \forall i = 1, 2, \ldots, I; \;\; j = 1, 2, \ldots, N_i - 1; \;\; k = j+1, \ldots, N_i, \tag{4}$$

$$\sum_{v=1}^{V} t_{vij} = z_{ij}, \forall i = 1, 2, \ldots, I; \;\; j = 1, 2, \ldots, N_i - 1; \;\; k = j+1, \ldots, N_i, \tag{5}$$

$$\sum_{i=1}^{I} \sum_{j=1}^{N_i} t_{vij} \le \Omega_v \xi_v, \forall v = 1, 2, \ldots, V, \tag{6}$$

$$z_{ij}, t_{vij}, \xi_v = \{0, 1\}, \forall i = 1, 2, \ldots, I; \;\; j = 1, 2, \ldots, N_i; \;\; v = 1, \ldots, V, \tag{7}$$

$$\tau_{ijk} = \{0, 1\}, \tau_{i,N_i,N_i+1} = \{0\}, \forall i = 1, 2, \ldots, I; \;\; j = 1, 2, \ldots, N_i - 1; \; k = j+1, \ldots, N_i; \tag{8}$$

$$w_l \ge 0, \forall l = 1, 2, \ldots, L. \tag{9}$$

Constraint (2) is the demand function of each product. Constraint (3) ensures that a component is either used or replaced, but not both. Constraint (4) ensures that only procured components are used to replace other components. Both (3) and (4) guarantee that the demands for all components are satisfied. In addition, they meet the one-way substitutability constraint, which ensures that a higher-functionality component can replace a lower-functionality one, but not vice versa. Constraint (5) indicates that a component is procured from exactly one supplier. Constraint (6) sets the value of ξ_v as 1 on the condition that the supplier v supplies a component. Constraint (6) also ensures that the number of different types of components supplied by the supplier v is no greater than Ω_v. Value ranges of all variables are set by constraints (7), (8), and (9).

The supplier faces the cost of raw material purchasing, cost savings from innovation, and investment for component innovation. Here, $\sum_{l=1}^{L} z_{ij} \left(u_{ijl} + \sum_{k=j+1}^{N_i} u_{ikl} \tau_{ijk} \right) q_l t_{vij}$ is the total number of the component L_{ij} used for all products. The following profit function is considered for the supplier:

$$\text{Max} \;\; \pi_v = \sum_{l=1}^{L} \sum_{i=1}^{I} \sum_{j=1}^{N_i} \left(p_{vij} - c_{vij} + r_{vij} \rho_{vij} \right) z_{ij} \left(u_{ijl} + \sum_{k=j+1}^{N_i} u_{ikl} \tau_{ijk} \right) q_l t_{vij} - \sum_{i=1}^{I} \sum_{j=1}^{N_i} \psi_{vij} {\rho_{vij}}^2 \tag{10}$$

s.t.

$$p_{vij} \geq 0,\ \ \rho_{vij} \geq 0,\ \ \forall i = 1, 2, \ldots, I; j = 1, 2, \ldots, N_i - 1. \tag{11}$$

To calculate the equilibrium, the authors first calculate the best reaction function of each supplier, after which the authors determine the manufacturer's optimal decisions based on the suppliers' best reactions. GA is an efficient meta-heuristic algorithm with simple computation and robust search abilities for optimization problems [2]. The decision variables involved in the optimization model include continuous variables and 0–1 integer variables. The optimal values of the continuous variables are difficult to obtain by a genetic search alone [17]. Thus, the authors first process the discrete variables in the heuristic search. Then, a nonlinear programming routine is used to determine the optimal value of the continuous variables by the given setting of discrete variables.

The authors adopt integer-coding chromosomes. A chromosome consists of the L section. The lth section contains the information related to the lth product, thus being composed of I units of SCSs. Each unit consists of two parts: the jth component selected for the current SCS and the vth supplier selection for the component in the SCS. The selected components and suppliers are encoded as integers in the genes of the individual. The supplier genes are created randomly, and the component genes are randomly created between 1 and the minimum component requirement from the product variant to maintain the variety of the population.

Given an encoded individual, the fitness value is calculated as follows.

First, the genes of an individual are decoded according to the representation scheme of the chromosome, and the 0–1 variables $z_{ij}, t_{vij}, \xi_v, \tau_{ijk}$ are set.

Second, π_m is solved using the value of the given variables; thus, the optimal solution w_l can be obtained.

Finally, the value of π_m and the fitness function of the individual are calculated by the equation: $F = \frac{\pi_m - {\pi_m}^{\min}}{{\pi_m}^{\max} - \pi_m}$.

The uniform crossover method [18] is employed in this paper. First, a crossover mask with 0–1 values is randomly generated for the genes of a chromosome. The units of the parents, which include the component and its supplier, are swapped if the corresponding mask value is equal to 1.

An individual of the current population mutates under a given probability. The mutation process iterates all genes of the individual, selects some genes randomly, and randomly transports each of the selected genes of the individual to one of its neighborhood individuals. The neighborhood of an individual is defined as a change of either of its genes to the neighborhood of this gene. The neighborhood of a gene is defined as the incremental or decremental change in the integer values contained in the current gene within 1 and the minimum configuration requirement.

The authors employ the roulette selection method to select individuals randomly. An individual with a larger fitness function value has higher probability of being selected as a parent to produce an offspring in next generation. The selected individuals enter into the mating pool for a crossover. The selection process continues until the size of the mating pool reaches the upper bound.

The chromosome-repairing mechanism is employed to repair the chromosomes generated from an initiation, crossover, and mutation. The basic idea is to search the neighborhood of the individual in order to distinguish the individual with the highest fitness function value to replace the original individual.

GA search terminates as the number of generations reaches a predefined number of loops.

4 Discussion

To demonstrate how the proposed mathematical model can be used to support a decision in investigating the component and supplier selection, remanufacturing, and pricing decisions in a green supply chain, the authors present and discuss a specific case application adapted from the number example of [19].

Using the mathematical model and solution algorithm presented, the optimal configuration, pricing, and remanufacturing decisions are reported in Table 1.

Based on the computational results and analyses presented above, several managerial implications are proposed.

First, as the market potential of one product increases, the manufacturer tends to configure the product closer to the minimum functionality required by the market. This finding indicates how the manufacturer configures the products according to the different market potentials.

Second, as market potential is enhanced, the supplier invests more in remanufacturing if he can be selected for the same component(s). This result signifies that the

Table 1 Optimal results of base example

(a) Optimal configuration, pricing decisions, and demands

		SCS 1	**SCS 2**	**SCS 3**
Product 1	Component	2	4	3
	Supplier	1	13	1
	Product price	303.10		
	Demand	6,897		
Product 2	Component	4	3	2
	Supplier	12	6	1
	Product price	757.71		
	Demand	18,064		

(b) Optimal remanufacturing decision

Supplier	**Fraction of the maximum cost reduction**
1	ρ_{12} (0.0374), ρ_{32} (0.0437),ρ_{33} (0.0250), ρ_{43} (0.0062)
6	ρ_{23} (0.0686)
9	ρ_{41} (0.0025)
10	ρ_{63} (0.0686)
12	ρ_{14} (0.0312)
13	ρ_{24} (0.0811), ρ_{53} (0.1123), ρ_{62} (0.0624)

remanufacturing investment is closely related to market potential. A better market environment would attract the enterprises to invest more in remanufacturing.

Finally, a larger maximum cost savings of one component could enhance its chance to be selected for the products. This condition implies that the supplier could enhance his possibility to be selected by improving the maximum cost savings of his components.

5 Conclusion

In this paper, the authors consider the coordination among suppliers and components selection, pricing, and remanufacturing decisions in a two-level green supply chain consisting of multiple suppliers and one manufacturer. This coordination problem is modeled as a Stackelberg game model. The authors use the analytical method and GA to derive the optimal decisions of all the chain members. A numerical example is studied to examine the game model and solution algorithm.

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Innovative Diffusion in Stochastic Lotka-Volerra System

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Abstract This paper investigates the reason why some green innovations are more apt to failure, even that they do possess obvious advantages and strong government support initially. The coopetition diffusion model establishes views of external benefits. The coopetition between manufacturers and remanufacturers, with a market demand fluctuation, is described in this model through a stochastic differential game of a Lotka-Volerra system. We highlight the successfulness factors from literature and characterize product natures and customer segmentation in terms of green innovation. We further postulate that diffusion will not sustain if necessary factors do not interact at the right accordance, that is, product nature, product launch strategy and timing have to be aligned well. Furthermore, we conclude that certain launching conditions and distribution fragmentation have to be met for various categories of green innovations and its competitive alternatives. For decision makers of a green product firm, we offer a concrete suggestion for the product launching strategy given observation on market competition, consumer acceptance and government support. Compared to previous studies that focus on competition analysis, this study considers diffusion of green innovation. We successfully link the product distribution dynamics to green innovations in a NPI process, which is otherwise difficult to be observed in other research.

Keywords Complementary product • Diffusion threshold • Diffusion velocity • Government subsidy • Multi-market competition • Stochastic Lotka-Volerra system

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1 Introduction

Some green innovations possess obvious advantages while some exhibit trade-offs. The highly risky green innovations, different from general innovations, often get support by governments or are protected by the law [1]. The resulting products, however, are not necessarily sustained simply because of technology maturity or heavy subsidies [2]. This paper investigates the subtle conditions for sustainability and also predicts the result of diffusion strategies on launching products in a competitive environment.

Most related research in the past focused on static game analyses from a competitive point of view when pondering the ideal policy for manufacturers [3]. As the resulting static equilibrium overlooks diffusion effects it is usually only suited for explaining short term market equilibriums and cannot provide for long term strategy and product sales adjustments for firms [4].

An innovation with only superior technology is unlikely to success and sustain. Thomas Edison's success in incandescent light represents a classical example in surviving between alternative innovations [5]. Defying to common acknowledgment, his success attributes to a correct business strategy instead of purely technology breakthrough [6]. In that time, he did not only confront strong abatement from gas utility collusion but, more importantly, no household has electricity connected to it. Literately speaking, he invested an immature innovation among incumbent technologies [7]. The entrepreneur Edison and the company have begun to be sustainable by switching on the Pearl Street, which provided electricity to 59 customers in a proximity region of lower Manhattan [8].

We highlight the success factors from literature and characterize product natures and customer segmentation in terms of green innovation, deriving the common attitudes and competitive strategies from them [9, 10]. We further postulate that diffusion will not sustain if necessary factors do not interact at the right accordance, that is, product nature, product fragmentation and segmentation strategy have to be aligned well in a competitive environment.

2 Problem Description in Stochastic Differential Game

Differential Games combine the concepts of Game Theory and Dynamic Control Theory and has been widely used in economics and management sciences [6]. When dealing with player objective conflicts its greatest advantage is the ability to effectively distribute resources based on opponent strategy information, hence achieving the ultimate goal in the dynamic system. It is especially used investigating long-term dynamic negotiations between participants [11].

Differential game models could be divided into two types, the deterministic differential game and the stochastic game. In comparison to the deterministic differential game, the stochastic differential game considers both state and stochastic dynamics, which better confirms the game model to real-life situations [12]. Because the stochastic differential game considers both competition between firms and uncertainties of consumer demands, recent studies have begun to apply this method as a tool for strategic interactions between upstream and downstream firms in a supply chain., for example, discussed the strategic interactions of pricing and advertisement between suppliers and retailers using the Stackelberg model of a stochastic differential game. By taking into consideration uncertainty factors of consumer demand functions, firms can achieve analytical results that better conform to real-life situations when deciding on optimal strategies [13–15]. This further verifies the fitness of the stochastic differential game in analysis of strategic interactions between upstream and downstream firms in a supply chain.

In the competitive structure of a game, both parties aim for maximal profit. Manufacturers mainly profit from host and tied product sales gains, which is represented by two functions, $r_1(p_1, x_1)$ and $r_2(p_2, x_2)$. Prime cost expended by manufacturers consists of three parts: production cost $v_1(x_1)$ of the host product, production cost $v_2(x_2)$ of the tied product and compatibility control expenses $h_i(\theta)$ of the two products. Host and tied product compatibility control expenses include costs for production procedure alterations and product protection devices, assuming that the cost is a increasing convex function with respect to compatibility. ρ represents the discount rate of the net present values in maximal manufacturer profits. Manufacturer profits can be represented in (1):

$$\pi_M = \int_0^{\infty} [r_1(p_1, x_1) - v_1(x_1) - h_1(\theta) + r_2(p_2, x_2) - v_2(x_2) - h_2(\theta)]dt \quad (1)$$

Remanufacturer profits arise simply from remanufactured tied product sales, whose function is represented by $r_3(p_3, x_3)$. Remanufacturer prime costs consist of two parts: product cost of remanufactured tied products $v_3(p_3, x_3)$ and product compatibility costs $h_3(\theta)$, which includes expenses for product development and production procedure alterations. Remanufacturer gains are the result of remanufactured tied product sales minus production and compatibility expenses, the function of which is assumed to be a decreasing convex function to compatibility decreases. Remanufacturer profits could be presented by formula (2):

$$\pi_R = \int_0^{\infty} e^{-\rho t} [r_3(p_3, x_3) - v_3(x_3) - h_3(\theta)]\, dt \quad (2)$$

Sales dynamics of products under a market strategy's basic idea is the influence of price and compatibility strategy manipulations on product sales volume by both parties, modified according to the model of this research. In a competitive system, although compatibility controlling manufacturers compete with remanufacturers in the tied products market, growth possibilities of host and tied product sales volume increases at the same time, demonstrating coopetitive diffusion of both product sales dynamics.

Due to difficulties describing product coopetition relationships between firms using the Bass model, many researchers have begun to apply ecological models to make up for deficiencies and restrictions in the former. Leoncini [16] studied the application of ecological models on business management and discovered that the ecological Lotka-Volterra model can be effectively used in business competition prediction and management. Furthermore, in [16] study on market segmentation of both products, quantified experiments verified the credibility of the Lotka-Volterra model and proved that close description of market evolution may be achieved; this study also demonstrates how business coopetition and Lotka-Volterra modeled evolution are consistent in nature. This research also applied the Lotka-Volterra model in market evolution relationship descriptions between manufacturers and remanufacturers to master the vicissitudes of evolution between them under interactions of different variables [17]. In this study sales volume diffusion dynamics is based on the Lotka-Volterra coopetition model.

This study established the dynamics of competitive diffusion based on a mutualism model and included stochastic terms to discuss coopetitive relationships of firms, as shown in formula (3), (4), and (5).

$$dx_1 = \alpha_1 x_1 \left[(Q_1 - x_1) + \delta(p_2, p_3, \theta)(x_3) \right] + \sigma_1(x_1)\, dz(t) \tag{3}$$

$$dx_2 = \alpha_2 x_2 \left[(Q_2 - x_2) + e_2 x_1 - f_2(p_2, p_3)(x_3 - g_2(\theta)) \right] dt + \sigma_2(x_2)\, dz(t) \tag{4}$$

$$dx_3 = \alpha_3 x_3 \left[(Q_3 - x_3) + e_3 x_1 - f_3(p_2, p_3)(x_2 - g_3(\theta)) \right] dt + \sigma_3(x_3)\, dz(t) \tag{5}$$

x_1 and x_2 each represent manufacturer host product and new tied product sales dynamics, whereas x_3 represents remanufacturer new tied product sales dynamics. α_i, $i = 1,2,3$ is this market intrinsic growth rate of products of both, and is assumed to be a constant uninfluenced by controlled variables. Q_{i}, $i = 1,2,3$ stands for maximal market sales volume, a.k.a. market saturation volume. $\sigma(x_i)$, $i = 1,2,3$ is variance term. $z(t)$ represents a standard Wiener process in probability $(\Omega, \Im, P)$.

3 Strategic Analysis

Consider the coopetitive game between a manufacturer and remanufacturer. The manufacturer first determines new item prices and compatibility strategies; the remanufacturer decides the remanufactured item price at the same time. Thereafter the manufacturer revises its product strategies and attains a Stackelberg game with optimal strategy manipulations and sales profits [18].

When the two markets are conditionally imbalanced and different in market competition extents, manufacturers could achieve total sales profits greater than that of a dependent market if moderate remanufacturer intervention is allowed by price and compatibility strategy adjustments.

In real-life market competition, there often exist distinct competence differences between firms. Those with better competition foundations lead product sales, most being able to promptly dominate the market because of their advantages; firms of later market entrance respond strategically as market followers according to market trends and leading firms' tactics. With the advantages of pioneering sales, manufacturers act as leaders in the tying product industry. On the other hand, remanufacturers must evaluate market demands for remanufactured goods before product release or consider the strategies of manufacturers when proposing responding tactics. This research models the Stackelberg game, builds a symbiotic Lotka-Volterra Stochastic dynamics system as a basis for the stochastic differential game model, and solve for optimal solution through an HJB equation in dynamic programming.

Establish a systems of equations, which leads to a solution for costate variables of both firms, and further solve for manufacturer ideal strategy p_2^* and $\theta*$ and remanufacturer ideal strategy p_3^*. However, costate variables of the model in this study are complicated and difficult to solve directly. Hence we divided product sales dynamics into shift terms and stochastic terms and adopted the Pontryagin Maximum Principle to solve dynamic systems concerning only shift terms. We then entered costate variable solutions into SDE (Stochastic differential equation) tools in Matlab, which led to optimal control solutions in a deterministic differential game. Thereafter we substituted first-order conditional control solutions derived from HJB equations into a stochastic differential game and model manufacturer sales dynamics and game expectations.

To examine market scenarios with a single manufacturer present, set remanufacturer-related influence coefficients as zero, which represents the absence of remanufacturer in this market. Assume that host product and tied product market sales volume are equal to start with ($x_1^0 = x_2^0$).

Among product sales dynamics parameters, set the level of beneficial effects of host product sales on tied product sales (k_3) as 0.5. In addition, host product original market growth (α_1) is set to be 0.25. Tied product intrinsic growth rate (α_2) is acquired via the simulation method by assuming that it follows a random process and its value being a random number that falls in the range [0.25, 0.4] and, by simulation, finding its random variation pattern within the target time. Find manufacturer expected returns through 30 parameter simulation tests, the other related parameter settings as shown in Table 1:

Table 1 Parameters for the case of single manufacturer

Parameter	Manufacturers	Remanufacturers
a	$a_1 = 0.25$; $a_2 = [0.25, 0.4]$	$a_3 = 0$
x^0	$x_1^0 = 2; x_2^0 = 2$	$x_3^0 = 0$
Q	$Q_1 = 6$; $Q_2 = 6$	$Q_3 = 0$
k	$k_1 = k_2 = k_4 = 0$; $k_3 = 0.5$	$k_5 = k_6 = 0 = k_7 = k_8 = 0$
σ	$\sigma(x_1) = 0.3$; $\sigma(x_2) = 0.3$	$\sigma(x_3) = 0$

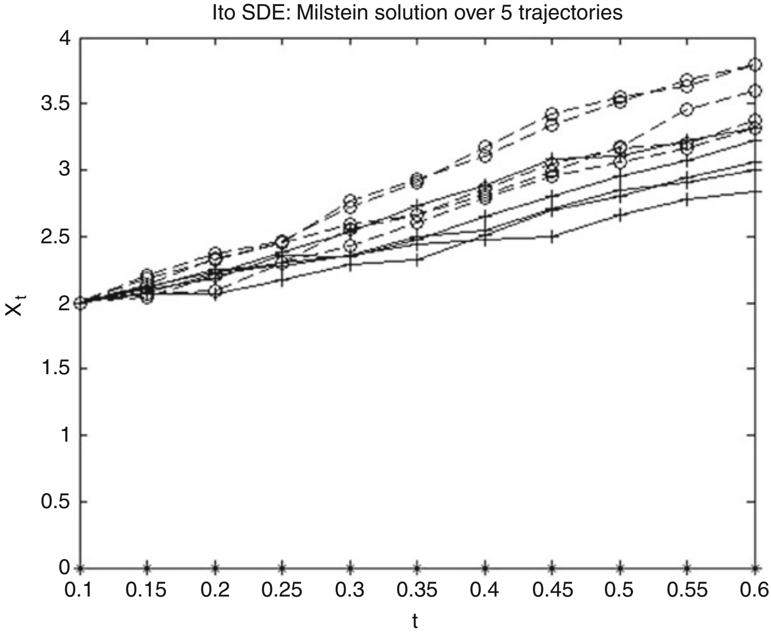

Fig. 1 Product sales dynamics in a single-manufacturer market

Conditioned that there is no remanufacturer present in the market, we randomly picked out a settings ($\alpha_2 = 0.3506$) from the 30 Monte Carlo simulation samples and observed the strategic manipulation, changes in sales volume and in sales profit. For strategic manipulations, firms can attract consumer usage by first adopting lower tied product price (p_2) penetration strategies and gradually returning to the market price with time. It is not necessary to set a tied product forbearance strategy θ when no remanufacturer is present, as shown in Fig. 1. From manufacturer product sales we observed that host product sales (x_1) can grow from two at an early stage to 3.4 in later stages. On the other hand, tied product market sales (x_2) grew from an initial value of two to a final value of three. Both products exhibited a trend for gradual sales growth, as evident in Fig. 1.

4 Conclusions

This study combines evolutionary properties of market needs and manufacturer ideal strategies and established a coopetition diffusion model that conforms to market dynamics for manufacturer reference when facing remanufacturer intervention. From model observations we find that, if manufacturers are competent for market competition and strategy manipulation, strategic control of remanufacturer intervention can bring about sales profits other than those from competition. But as market competition conditions and consumer demands for complementary items change, manufacturers should modify their ideal product strategies accordingly to achieve optimal competitive diffusion results of both products.

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Scenario Planning and Implementing of a Dairy Cattle UHF RFID Management System

Yu-Shing Chang, Y.S. Lin, N.C. Wu, C.H. Shih, and C.H. Cheng

Abstract Since Chinese Taipei joined the World Trade Organization (WTO) membership in year 2001, the global economy and trading activities have become more competitive in Taiwan, while the food safety and supply chain management have also developed into important management issues in the world. Therefore, with the intention of developing its cattle industry, the Taiwanese government has invested considerably in Information and Communication Technology (ICT) to enhance farm management efficiency and support the internal growth of its Radio Frequency Identification (RFID) industry. Recently, RFID has been attracted widespread hope, hype and optimism, and hailed in the mainstream media as a revolutionary technology. This case study introduces a cattle management pilot project using Ultra-high frequency (UHF) RFID technology to assist farmer's cattle management and identification, and enhance process and efficiency in the milking rooms. The deployment experiences and solutions can be utilized as a reference for further study and the cattle management automation industry.

Keywords Cattle management automation • Radio frequency identification • Ultra-high frequency

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1 Introduction

In line with the rapid increase in the global economy and international trading, many governments now focus on the process of controlling the safety of their food chains when implementing their policies and this has become an important marketing issue. For example, the outbreak of poisonous milk powder containing melamine in China had a seriously negative impact on domestic consumers' confidence in food safety, and although China's Department of Health has undertaken a great many examinations in an attempt to guarantee the absolute security of on-shelf products, this has failed to influence most people's willingness to buy food that contains milk. As for other countries, there are many different opinions of whether or not to import or export beef, since this has a certain effect on politics, economy, and food safety. Therefore, governments are tending to apply new ICT technology, as well as new control measures, to improve individuals' effective management of cattle and the general traceability of beef [1, 2].

Radio Frequency Identification (RFID) has recently become a very popular issue in the field of Information Technology [3]. RFID technology has been used to electronically tag the ears of livestock to facilitate tracking since 1985, when the first case of Mad Cow disease (Bovine spongiform encephalopathy, BSE) was found in Kent, England, and this has gradually become a traceability tool for food inspection, recording pollution, and controlling the inventory to improve food security and productivity, as well as save operating costs [4, 5]. For example, in their study, Samad et al. [6] found that using RFID tags to create a database enabled farmers to develop more effective management in terms of various checks and records for animals. Chansud et al. [7] and other scholars also support the RFID system as being faster, more concise and easier to operate than conventional systems when tracking livestock transportation. Strict feeding and high-quality dairy production management is extremely important for dairy farmers, and using an RFID technology-based management system enables them to resolve many traditional management problems, such as better cattle identification and tracking, an easier resolution of dairy insurance claims, and less difficult insurance company investigations [8].

In summary, as a new form of technology, Radio Frequency Identification (RFID) is now widely used in modern, large-scale farming, where it plays an important role in information management, database creation, food security, disease control, identifying and tracking cattle, and preventing insurance fraud. Dairy farming not only needs to become technological, but it also needs to become international and connected with the wider world. Therefore, how to use RFID technology to improve the quality of their work and management efficiency has become a key issue for the survival of dairy farmers.

While the RFID traditionally used in dairy farming was limited to low-frequency and high-frequency, UHF is an emerging research direction. The greatest transmission distance of its passive tags is from 3 to 5 m, which is longer than that of low-frequency and high-frequency RFID, and in addition to dramatically increasing the level of application, it also costs less. Therefore, the Taiwanese government has begun to implement UHF RFID technology in dairy farming operations for the very first time in conjunction with the Dairy Association Taiwan, R.O.C., as well as the well-known RFID company, ClarIDy.

This research describes the way in which ClarIDy Solutions assists the Taiwanese Dairy Association in the planning of a “Cattle identification management hardware purchasing environment”. By implementing RFID in the milking room’s automatic cattle identification system of eight middle-sized cattle farms, the system is able to control information about the cattle’s quarantine, feeding, dry period, and quality of milk. It is also used to monitor cattle that are not suitable for milking, thereby improving dairy farmers’ operating efficiency and the safety and quality of the milk, as well as assisting the government to prevent possible epidemics and enhancing dairy farmers’ performance. This paper contains five sections, the first of which is Sect. 1 “Introduction”. This is followed by Sect. 2, “Restrictions of the application of RFID technology”, Sect. 3, “Scenario planning of a dairy cattle RFID management system”, Sect. 4, “The function of an RFID system in managing dairy cattle”, and finally, Sect. 5, “Conclusion and recommendations”.

2 Restrictions of the Application of RFID Technology

There has been an upsurge in the demand for RFID since 2003 because of an announcement by Wal-Mart, DoD and Tesco that all their suppliers needed to provide goods equipped with RFID tags. All seats were occupied in RFID seminars held both at home and abroad. However, RFID still lacks distinctive standards for radio frequency regulations, hardware, software and information networks in various countries, and suffers from issues of high cost, low ROI (Return on Investment), non-mature radio technology, etc., [9]. The main problems of industrial applications are described below.

2.1 Radio Frequency Regulations Depend on the Jurisdiction of Various Countries, and the Spectrum of Regulations in Different Countries Is Inconsistent

Countries are gradually loosening the limits of the UHF band [10], so that RFID cannot only operate around the world at 13.56 MHz and 2.4GHz, but can also be used on a UHF band, which means that they can be read over longer distances. Nevertheless, because every country facilitates the use of different frequencies (902–928 MHz in U.S., 922–928 MHz in Taiwan, 954–956 MHz in Japan, 868 MHz in European, RFID journal news, 2004), ISO-18000 defines a range of 860–960 MHz when RFID is used over a UHF frequency. This means that if tags are attached to goods that are meant to be sold throughout the world, the spectrum of the tag antenna must be capable of a large coverage; as a result, the technical design of the tag antenna is relatively important.

2.2 Problems with RFID Technology Affects the Read Rate

RFID technology tries hard to overcome the limitations of the read range and read rate [11]. For example, when it is used over an 860–960 MHz UHF band, some materials absorb the energy of the radio waves (such as water or conductive aqueous solution products), while some cause reflectivity or refrangibility (like metal products or glass products), and still some materials (such as plastic products) divert the transmission radio waves to a different frequency band. Furthermore, flat antennae cause directional problems for readers and tags when transferring energy. The design of the tags' antennae must consider the permittivity of the material attached to the tag and the selected chip's impedance in order to optimize the matching ability. However, there is still a shortage of domestic suppliers with extensive experience in this field.

2.3 Issue of the Integration Between Hardware and Software, and IT Application Services

EPC Class 1 Gen. 2 are the set standards in EPCglobal [12]. The read rates and costs, which are better than in the past, were sent to the ISO (International Standards Organization) to form the ISO 18000-6C standard. The standards of EPCIS (EPC Information Services Standard) and ONS (Object Name Service) have been announced for information systems, so that a link can be created to the operating standard of the original DNS (Domain Name System). However, it may be difficult for the EPCIS to have a clear specification to achieve compatibility in the short term because this involves competition among IT software giants such as Microsoft, Oracle, IBM and Tibco. For example, in the application to domestic dairies, the coding of ear tags can use uniform governmental serial numbers, dairy farmers' codes and EPC codes. The dairy industry needs a united coding standard in any case so that the promotion and services of the system can be more diverse and value-added without being limited to a specific closed application field. This will provide an opportunity to follow up valuable services.

2.4 Costs Cannot Be Reduced to a Reasonable Price in a Short Time

Experts forecast that the price of RFID cannot be reasonably reduced in a short time because the design and packaging material of an RFID Tag is usually customized on the basis of the different materials to which it is attached. Moreover, it is difficult to drastically reduce the unit price of a tag without a certain amount of procurement to share the cost of developing an antenna module and packaging mold to manufacture the tag [9, 13, 14]. The reading efficacy of the reader antenna is easily affected by the environment and it also needs to be adjusted to be suitable for local circumstances. In addition, the system architecture and the planning and the implementation of back-end IT (Information Technology) require a standardized application to reduce the costs of system integration and software development. Consequently, the key to the future of RFID in Taiwan's dairy industry lies in dairy farmers and the government working together to implement an integrated application.

2.5 Summary

To reduce the restrictions of the application of RFID technology in dairy industry, the government has devoted to cooperate with the Dairy Association Taiwan, R.O.C., as well as the well known RFID industry company, ClarIDy in order to implement UHF RFID technology in dairy farming operations in the planning of a "Cattle identification management system and environment".

3 Scenario Planning of a Dairy Cattle RFID Management System

According to the Dairy Association's required specifications and site survey, a demonstration scenario is planned as shown in Fig. 1.

In this case, the basic functions of the planned application scenarios are described below.

(a) When the cattle are ready for milking, they will be driven to enter from the waiting area into both sides of the milking area. Then, the fixed readers on the aisles will recognize the RFID tag number, and display the number on the LED (Light Emitting Diode) monitors.
(b) The LED monitors used to display the RFID tag number are required to be able to amend and replenish any unread numbers.
(c) The numbers read will be displayed on LED monitors. When the reading fails, managers can use a handheld PDA to select the milking machine's position, and then reinsert the failed number.
(d) When one row of cattle (left or right) is finished milking, the next batch will accept the read message. At the same time, the LED and PDA monitors will automatically clear that side of the numbers, and be ready to accept the next batch of readings.

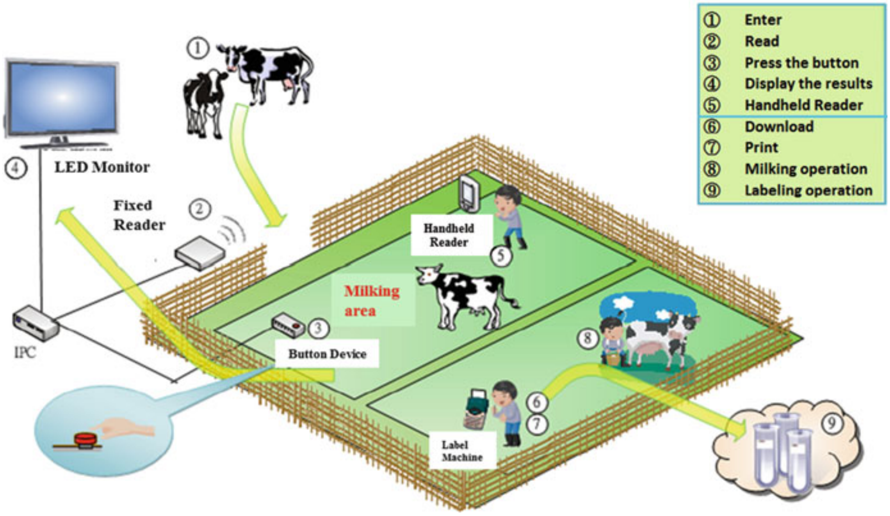

Fig. 1 Application diagram

(e) An IPC (Industrial Personal Computer) will integrate and record the tag ID (Identity) and time from the readers, and upload them to the DHI (Dairy Herd Improvement) so that the DHI assistants can promptly master the milking situation; thus, increasing the effectiveness of the work.

4 Function of an RFID System to Manage Dairy Cattle

4.1 Plan of the System Architecture

The system architecture mainly involves establishing an RFID reader system and IPC in the dairy farmer's operational area (milking room), and a DHI system in the Dairy Association Office (as shown in Fig. 2). When the data is read from the RFID Tag, it is sent to the IPC and displayed on the LED monitor. It even uses a wireless network node AP to connect the wireless label printer and hand-held PDA reader so that the user can work more easily in the operating area. The approach to connect the wireless label printer and hand-held PDA reader is shown in Fig. 3, and the current hardware of a milking room in this case is shown in Fig. 4.

Data from both the fixed reader and hand-held PDA reader is connected to the data processing center of the DHI by the internet. Dairy farmers can also download the processed DHI data, such as abnormal cattle warnings from the data processing center; otherwise, it can be downloaded to a handheld PDA for cattle management, such as assessing the volume of milk input, feeding, disease prevention, input operation, etc., to increase the competitiveness of the dairy industry.

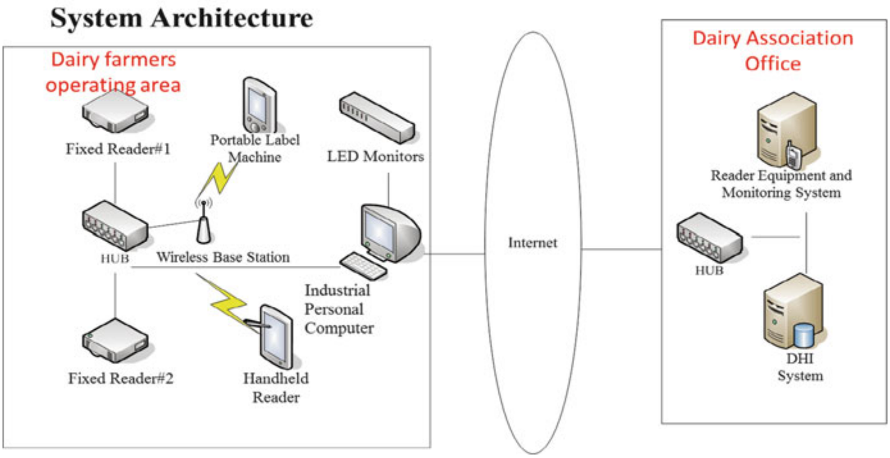

Fig. 2 System architecture chart

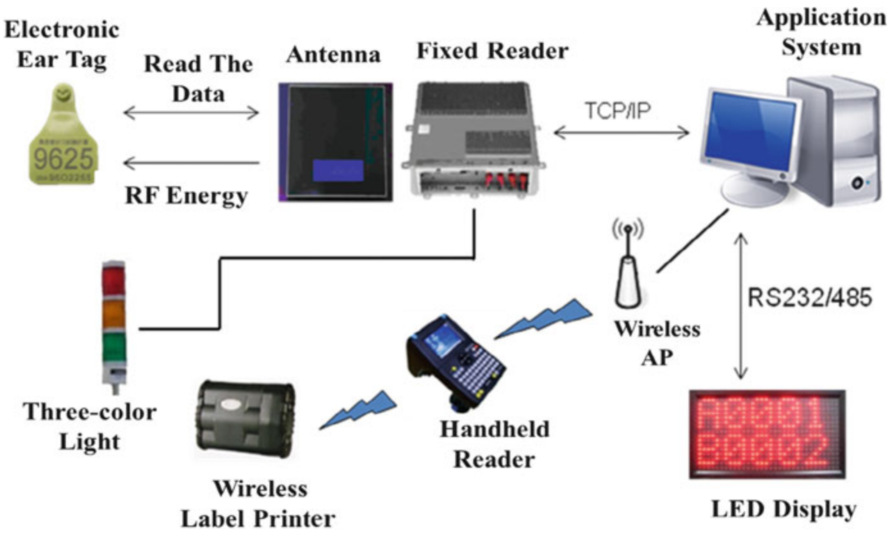

Fig. 3 The approach to connect the wireless label printer and hand-held PDA reader

4.2 Results of Establishing the System

The planning of an RFID system in milking rooms according to the application situation and functional requirements is as follows:

(a) The button is pressed to turn on the red light, which indicates that the Fixed Reader has started its reading function. Then the cattle sequentially pass through

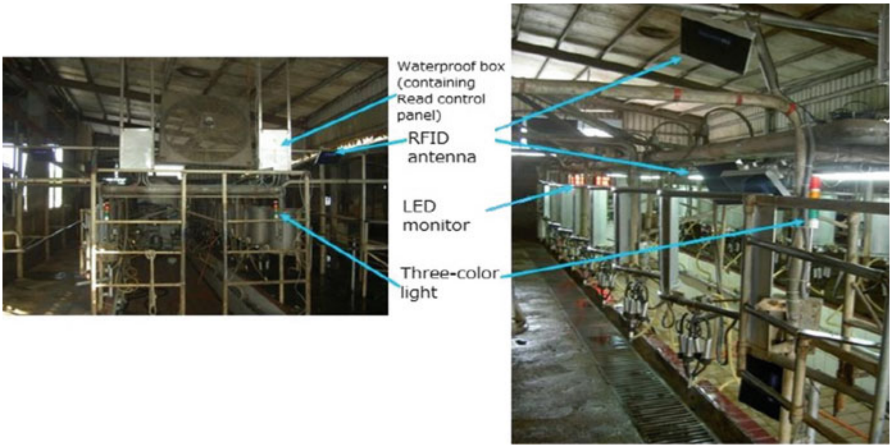

Fig. 4 Hardware of the milking room

the sides of the milking room from the waiting area, and the Fixed Reader recognizes the RFID electronic ear tag ID, which is displayed on the LED monitor in sequence.

(b) If the cattle read by the system are judged to be non-milking, the three-colored light will be yellow, and after 3 s, it will jump back to red. However, if the cattle are judged to be milking, the light will remain red.
(c) The cattle numbers that are read are directly displayed on the LED monitors, but if the Reader fails to read, the administrator can replenish the failed cattle numbers using a handheld device.
(d) When any row of cattle (on the left or right) reaches the permitted milking number, the three-colored light turns green, the fixed readers automatically stop reading and wait for the next batch of cattle to enter the milking area to squeeze the milk.
(e) The cattle ID read by these readers are recorded in the IPC after the IPC integrates the system time of the Reader and the ear tag ID.

4.3 *Brief Introduction of System Functions*

The system functions include the following planning framework (as shown in Fig. 5). The software development of the data processor in this project includes the following basic functional requirements:

(a) Basic data and device management module: the basic data of the RFID cattle and the dairy farmers, Fixed Reader effectiveness setting operations and data replenishing operations in the milking rooms read by hand-held PDA Readers.

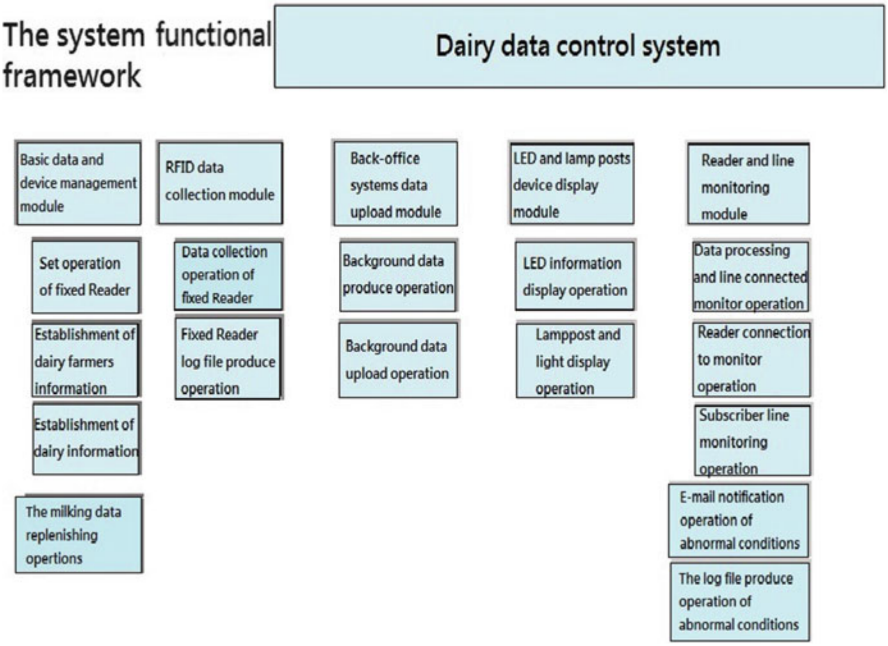

Fig. 5 Functional framework of the data processing and control system

Fig. 6 The LED monitor displays the cattle ID that has been read

(b) RFID data collection module: the operation of the Fixed Reader's data collection and the establishment of a Log File generation of the Fixed Reader. This module receives the tag information transmitted by the RFID fixed and hand-held reading device.

(c) A LED and lamp post device display module: the information cannot only be transferred and shown on the LED monitors (shown as Fig. 6), but abnormal

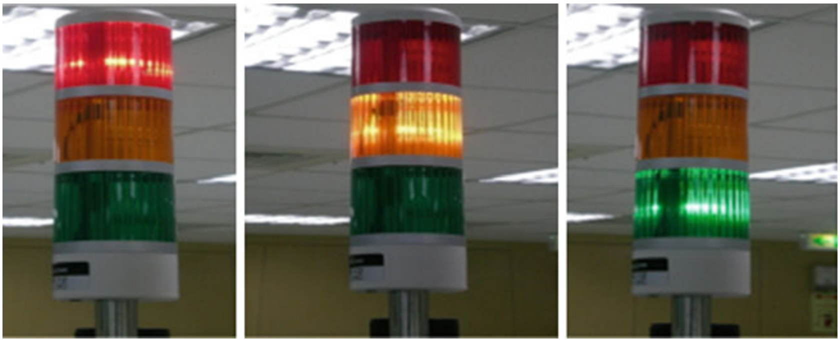

Fig. 7 Three-colored warning light (*Red*: begin to enter; *Yellow*: abnormal warning; *Green*: read complete) (Color figure online)

information can be shown and warned by a three-colored light (shown as Fig. 7) after reading the chip code within the ear tag, etc.

(d) Background data upload module: this transfers the signal/data to a background data server.
(e) Monitoring of the capabilities of the equipment and module lines, including the connective state of the system.

5 Conclusion and Recommendation

5.1 *Critical RFID Needs of Dairy Farmers*

(a) Provides the function of identifying the cattle to prevent abnormal cattle from entering the milking operation to increase the safety of dairy products. The most important applications of the milking room RFID system's read operation are as follows:

- Warning of abnormal cattle.
- Milking/disease prevention/feeding and traceability system.

(b) The RFID read rate can only save manpower because of its high rate of visual identification. The real focus is the convenience of mending the unread/input.
(c) Many RFID users (older people) are unfamiliar with computers, in which case RFID hand-held identification is considered to be hard to operate, when using a PDA screen to input data, as well as taking account of pasture staff's hand-eye coordination.
(d) A combination of DHI system software with a database function and a pasture management system is needed to enable the provision and display of real-time information after the read.

5.2 User-Friendly Design

(a) The LED display can be substituted by an LCD monitor, which is easy to use and colorful, and this can make it easier for users to recognize abnormal cattle with symbols or colors for dry periods, breeding periods, antibiotics, or other factors.
(b) It is not necessary to replenish the unread numbers using the RFID handheld PDA. To make it easier, it is proposed to use a wireless input keyboard that is similar to a computer keyboard, and it will only be necessary to enter left or right and the cow's number to operate it.
(c) The Smart-phone/PDA is effective for use in disease prevention/feeding operations.

5.3 Key Factors of Continual Promotion

The software/hardware implementation needs to consider the responsibility of the system integration. The integrated RFID has to take both the RFID and dairy farmers' operational professionalism into account, as well as the practical problems of dairy farmers/DHI management to find the best solution.

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An Application of ANP in the Selection of Supplier in Fishing Tackle Manufacturing Company

Po-Ya Tang and Jen-Der Day

Abstract Supplier selection of the fishing tackle manufacturing company is an important problem in Quanzhou, China, and the qualities of suppliers are uneven.

The objective of this paper is to choose the best supplier by evaluating quality, financial and location of buyer-supplier.

Analytic network process (ANP) is adopted to do the supplier selection. ANP incorporates the relationship of interdependence and feedback in the multilevel decision network and it provides a way to input judgments and measurements to derive ratio scale priorities for the distribution of influence among the factors and groups of factors in the decision. A ranking of the buyer-supplier weighted index is attained, and the results should provide opinion to select the most suitable for relationship between the manufacturer and its supplier. Based on supplier selection weighted index, the best supplier has been determined, and found that quality is the most important in rank of supplier's evaluation criteria. The result showed supplier B is the chosen one, since it can improve the manufacturer's quality, raw material, equipment status, and function of product. As the matter a fact, supplier B cannot only provide good quality but also provide on-time delivery, even though its location is the farthest one.

Keywords ANP • Supplier selection

1 Introduction

In today's increasingly competitive business world, selecting and evaluating the suppliers is one of the most important activities of a manufacturer. In China, many Taiwanese businessmen almost go there for reducing cost, such as the production

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costs and labor cost. The businessmen emphasis cost down, and it may cause instable quality, and reducing the company's reputation. The early years, the factories of Taiwan move to China, and Southeast Asia; the enterprise is nothing more than to reduce labor cost. Commercial quality requirements of the business world, consumers require not only factory goods low prices but also good quality. It's an important aspect how to choose good suppliers on business world in quality-oriented manufacturers. The manufacturing company with better suppliers needs to be formed to improve quality, flexibility as well as to reduce lead time. Supplier selection is a vital issue concerned in the process of managing global supply chains.

2 Methodology

ANP was developed by multiple criteria decision making (MCDM) for using a suite of criteria to solve a decision problem. Because these criteria may vary in the degree of importance, ANP is employed to prioritize the selection criteria (i.e. assign weights to the criteria).

AHP and ANP are two different method concepts by Saaty [1]. AHP is a vertical independent analysis, but ANP incorporates the relationship of interdependence and feedback. One of the main functions of AHP is to calculate the consistency ratio to ascertain that the matrices are appropriate for analysis [2]. ANP is a technique that overcomes the limitations of AHP. A holistic approach like ANP is required if all the attributes and alternatives are networked in a system to accept various dependencies.

ANP [2] comprises four main steps: (1) Conducting pair-wise comparisons on the elements at the cluster and sub-cluster levels; (2) Placing the resulting relative importance weights (eigenvectors) in sub-matrices within the super matrix; (3) Adjusting the values in the super matrix so that the super matrix can achieve column stochastic; (4) Raising the super matrix to limiting powers until the weights have converged and remain stable. The decision making process for the selecting suppliers has two stage; the first stage is constructing the selection model, including finding criteria and expert interviews. The second stage is using the selection model, including the decision-making tools.

Constructing selection model stage is to find out the criteria of supplier selection of the manufacturing company from the literature, and to do expert interviews to determine the main criteria of the architecture summarized. The criteria of literature is location, cost, physical features of port, hinterland economy, port efficiency [3], price, quality, delivery, technique [4], quality, service quality, delivery time, price respectively [5], cost, delivery performance [6], consistency (quality and delivery), reliability, relationship, flexibility, price, service [7], financial, equipment status, raw material, manufacturing quality, delivery, location [8], quality, on-time delivery, and performance history [9].

Using the selection model stage is to use the decision-making tools to obtain the various criteria' weights as selection criteria. In this study, the ANP is a decision making tool, the purpose is to find out the best suppliers of fishing tackle manufacturers in Quanzhou, China. The process of ANP in this paper has five steps:

1. Establish criteria cluster and factor node,
2. Establish pair wise comparison matrix and calculate the eigenvectors,
3. Calculated the relative weighting of each criterion,
4. The inconsistency (C.R. < 0.1) and sensitivity test, and
5. The results of the assessment.

2.1 Establish Criteria Cluster and Factor Node

The purpose of this research designed ANP model to choose the best suppliers. This research focused on the suppliers of the industrial company of the clustering effect cannot be scheduled for supply to manufacturers. For instance, manufacturing company A identifies the favorable conditions of the supplier of the manufacturer. According to the existing literature, we found that the necessary indicators in the selection of suppliers, and choose the necessary indicators as the criteria and sub-criteria for the company in this study. The Table 1 is criteria from the existing literature, and hierarchy for program supplier selection including the main criteria and sub-criteria is in Fig. 1.

2.2 Comparison Matrix and Calculate the Eigenvector

Satty [1] shows brought up a measurement scale with 9-point prior measurement specification: 1 means the two compared elements are equally important; 9 points means one of the elements has an overwhelming advantage. Point 1 means the degree of contribution of the two programs is equally important. Point 9 means there is sufficient evidence to certainly absolute preference to the other one.

2.3 Calculated the Relative Weighting of Each Criterion

Calculation process of ANP contains three matrices, there are unweighted supermatrix, weighted supermatrix, and limit supermatrix. Unweighted supermatrix obtained the weight from the right of the original pair comparison; weighted supermatrix means that the weight of the same elements within the unweighted supermatrix multiplied by correlative cluster weight. If the data of the unweighted

Table 1 Condition of supplier

Supplier A	Long-term cooperation, small-scale, sometimes delay in delivery
Supplier B	The farthest, good quality
Supplier C	Service (maintain)

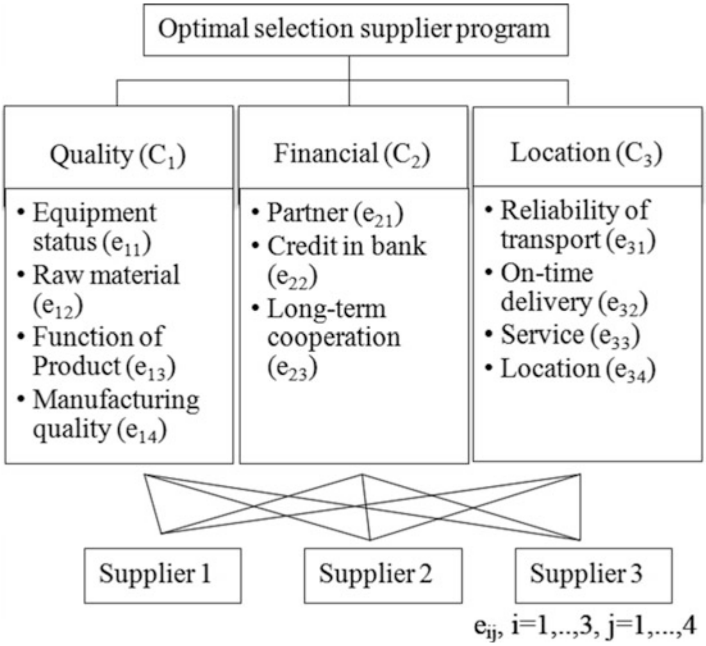

Fig. 1 Hierarchy for supplier selection program

supermatrix is one, at this time, the weighting supermatrix is not weighted supermatrix; ultimate supermatrix is squaring the weighting supermatrix several times to get each column identically. Let the components of a decision system denote C_k ($k = 1,2, \ldots, n$), let each component k contain m_k element, denoted by ($e_{k1}, e_{k2}, \ldots, e_{kmk}$), and let W_{ij} ($i = 1,2, \ldots, n$, $j = 1,2, \ldots, n$) denote the sub-matrix. Equation (1) shows a standard form of a supermatrix [10, 11].

$$
\begin{array}{cc}
 & \begin{array}{ccccccccc} & C_1 & & & C_k & & & C_n & \\ e_{11} & \cdots & e_{1m_1} & e_{k1} & \cdots & e_{km_k} & e_{n1} & \cdots & e_{nm_n} \end{array} \\
\begin{array}{cc} & e_{11} \\ & \vdots \\ C_1 & e_{1m_1} \\ \vdots & e_{k1} \\ C_k & \vdots \\ \vdots & e_{km_k} \\ C_n & e_{n1} \\ & \vdots \\ & e_{nm_n} \end{array} &
\begin{bmatrix} W_{11} & \cdots & W_{1k} & \cdots & W_{1n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ W_{k1} & \cdots & W_{kk} & \cdots & W_{kn} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ W_{n1} & \cdots & W_{nk} & \cdots & W_{nn} \end{bmatrix}
\end{array}
\tag{1}
$$

2.4 The Inconsistency (C.R. < 0.1) and Sensitivity Test

The matrix of pair-wise comparisons is determined subjectively by the decision-makers, due to the judgment level and many element, it is difficult to show consistency on the subjective determination. Therefore, these values are required to do consistency test and keeping the consistency index (Consistency Index, CI) [12, 13].

$$C.I. = \frac{\lambda - n}{n - 1}, \tag{2}$$

where n is the total of criteria, and $\lambda = \sum_{i=1}^{n} \frac{(AW)_i}{nW_i}, \quad i = 1, 2, \ldots, n$, where W_i is the matrix's eigenvector, and A_i is pairwise comparison matrix.

When the CI = 0, it indicates the determination is the same exactly, Saaty proposed CI <0.1 in the case, it can be considered to have a better consistency.

3 Results

3.1 Case Company – RENYO Fishing Tackle Manufacturing Company

The beginning of the early industrial development in Taiwan, due to human cost slowly raise, it has led many companies to move the factory abroad, including China, Southeast Asia, etc. They transferred manufacturing to reduce costs, such as the human cost, the cost of raw materials. However, they just wanted cost reduction and ignored quality.

Manufacturers of fishing tackle manufacturing industry had a large of original equipment manufacturing's order. But the manufacturer wanted to reduce labor costs, it migrated to China. In recent years, the one of the suppliers could not deliver on-time, it was causing the manufacturer lost reputation. Further found that this supplier has brought harm to the reputation of many fishing tackle manufacturers due to lack of funds and manpower.

The fishing tackle manufacturers in China are industrial agglomeration, and many fishing tackles need to this component. However, there are just three suppliers in this area. Table 1 showed the conditions of suppliers. The people of this questionnaire survey are the fishing tackle manufacturers in Quanzhou, China. A total of 35 copies are delivered, and 29 copies are returned.

The targeted population of this study was the CEO with experience choosing the supplier who made the Special component. A total of 35 copies are delivered, and 29 copies are returned. In 29 samples, the valid samples are 29. Among the 29

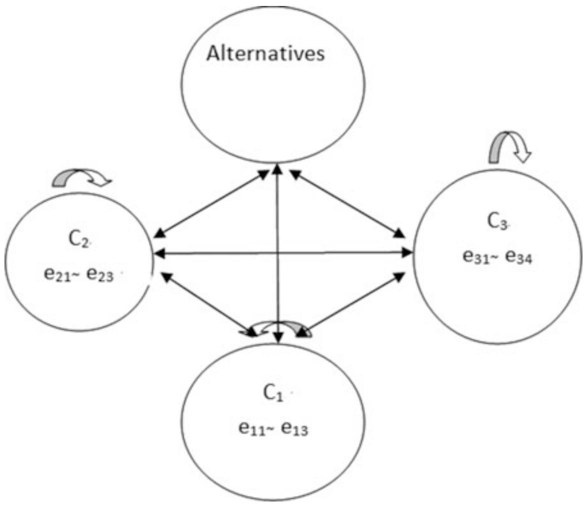

Fig. 2 Framework for ANP supplier selection process

respondents, 29 respondents (100 %) are males. Approximately 25 of the total 29 respondents (86 %) range in age from 50 to 60 years, others (14 %) are in age over 60 tears. The work experience of the respondents, 19 of them had 10–15 years of work experience (79 %), other have above 20 years of work experience (21 %).

3.2 Framework for ANP Process

The framework developed in this project consists of three supplier selection criteria, namely quality, financial and location. The various sub-criteria for supplier selection are also shown in Fig. 1. As a sample, quality (C_1) criteria consists of various sub-criteria namely equipment status (e_{11}), raw material (e_{12}), function of product (e_{13}) and manufacturing quality (e_{14}). Financial (C_2) criteria consists of various sub-criteria namely partner (e_{21}), credit in bank (e_{22}), and long-term cooperation (e_{23}). Location (C_3) criteria consists of various sub-criteria namely reliability of transport (e_{31}), on-time delivery (e_{32}), service (e_{33}), and location (e_{34}). Framework for ANP supplier selection process is shown below in Fig. 2.

3.3 Establish Pair Wise Comparison Matrix and Calculate the Eigenvectors and the Inconsistency (C.R. < 0.1)

This chapter was description the calculation process of the questionnaire. The first part is comparison with the criteria and sub-criteria relative, actually, the calculation process is a previous analysis hierarchy process method. It obtained the eigenvector.

Table 2 Eigenvector for comparison matrix for relative importance of each supplier for criteria

Criteria eigenvector W1				
	C1	C2	C3	Eigenvector w1
C_1	1	6	4	0.70097
C_2	1/6	1	1/2	0.10615
C_3	1/4	2	1	0.19288
C.I = 0.00885				

Table 3 Eigenvector for comparison matrix for various sub-criteria under 'quality' criteria

Sub-criteria W21					
	e_{11}	e_{12}	e_{13}	e_{14}	Eigenvector w21
e_{11}	1	1/3	1/4	1	0.108471
e_{12}	3	1	1/3	2	0.240087
e_{13}	4	3	1	4	0.531399
e_{14}	1	1/2	1/4	1	0.120043
C.I = 0.02333					

Table 4 Eigenvector for comparison matrix for various sub-criteria under 'financial' criteria

Sub-criteria w22				
	e_{21}	e_{22}	e_{23}	Eigenvector W22
e_{21}	1	4	1/4	0.217166
e_{22}	1/4	1	1/9	0.065769
e_{23}	4	9	1	0.717065
C.I = 0.00675				

Table 5 Eigenvector for comparison matrix for various sub-criteria under 'location' criteria

Sub-criteria w23					
	e_{31}	e_{32}	e_{33}	e_{34}	Eigenvector w23
e_{31}	1	1/7	3	2	0.156843
e_{32}	7	1	7	6	0.674975
e_{33}	1/3	1/7	1	1/2	0.064031
e_{34}	1/2	1/6	2	1	0.104151
C.I = 0.05478					

Table 6 Cluster matrix

	Alternatives	Financial	Location	Quality
Alternatives	0	0.207113	0.384618	0.477192
Financial	0.106146	0.079745	0.073798	0.053003
Location	0.19288	0.22719	0.125705	0.130708
Quality	0.700974	0.485952	0.415879	0.339097

And the sub-criteria used the calculation process of the analysis network process. Pairwise comparison matrix for dependencies between criteria and sub-criteria for each criterion is created, and eigenvector is calculated. Five such matrices have been developed. Sample calculation is shown in Tables 2, 3, 4 and 5.

After calculating the eigenvectors, integrating the eigenvectors into a matrix can get a cluster matrix (Table 6).

The unweighter supermatrix was from integrating all pair wise comparison matrix. Then, weighted supermatrix was from cluster matrix times unweighter

Table 7 The weight and priority of supplier's evaluation criteria

Name	Limiting	Ranking
e_{11}:Equipment Status	0.05434	3
e_{12}:Raw material	0.12385	2
e_{13}:Function of Product	0.04252	5
e_{14}:Manufacturing Quality	0.2174	1
e_{21}:Partner	0.01412	9
e_{22}:Credit in Bank	0.00804	11
e_{23}:Long-term Cooperation	0.05201	4
e_{31}:Reliability of Transport	0.02589	6
e_{32}:On-time Delivery	0.06516	8
e_{33}:Service	0.02832	10
e_{34}:Location	0.02656	7

Table 8 The weight and priority of supplier

Name	Limiting	Ranking
Supplier A	0.08963	2
Supplier B	0.16591	1
Supplier C	0.08627	3

Table 9 Overall weights of the supplier

Name	Ideal weights	Normal weights
Supplier A	0.540246	0.262227
Supplier B	1.000000	0.485385
Supplier C	0.519975	0.252388

supermatrix. According to the result of the Super Decisions software, it can be obtained the relative weight of the each suppliers' criteria, and then rank the relative weight from limit supermatrix. The detailed is shown in Tables 7 and 8. Table 7 showed the rank of supplier's evaluation criteria: manufacturing quality (0.2174), raw material (0.12385), equipment status (0.05434), long-term cooperation (0.05201), function of product (0.04252), reliability of transport (0.02589), location (0.02656), on-time delivery (0.06516), partner (0.01412), service (0.01412), and credit in bank (0.01412). Table 8 showed the rank of suppliers: supplier B (0.16591), supplier A (0.08963), supplier C (0.08627). In the last, Table 9 showed supplier B was the most suitable for RENYO fishing tackle manufacturing company.

4 Conclusion

Based on the analysis results, we first find that the rank of supplier's evaluation criteria is quality (0.700974), location (0.19288) and financial (0.106146) on Table 7. Although the better supplier – supplier B don't have good location, its' quality is the best. It is noted that the fishing tackle manufacturers are not only care for cost down but also concerned with quality.

In 1980, the manufacture was in the flourishing period, and the labor cost increased. The New Taiwan dollar appreciating; however, Taiwan was an export-oriented country. Therefore, the advantages of manufacturing Industries disappeared, so factories shutdown or moved out. Because China had low labor cost and the same language, fishing tackle manufacturing company moved to China. Furthermore, China has a regular exhibition of fishing tackle. The exhibition improves not only reputation but also competitiveness.

On facing today's pressure of competitive, Manufacturers do not only need to improve production capacity and efficiency but also combined with supplier for holding the demand of marketing. The decision making process for the selecting suppliers has two stage; the first stage is constructing selection model stage is to find out the criteria of supplier selection of the manufacturing company from the literature and to do expert interviews to determine the main criteria of the architecture summarized; the second stage is using ANP to get the eigenvectors. Due to practice selection suppliers of enterprises, there are too many criteria and factors, and they often exist dependencies and feedback relationships. This study used ANP model which considerate dependencies and feedback relations, and let results were more accurate for the reference of the practice.

Fishing tackle manufacturers established factories for raw materials and labors, but according to interviews, there were seven fishing tackle manufacturing companies moved because of the low raw materials or high labor issues. It caused the clusters situation became united; therefore, suppliers were not attracted to go there to established factories. The study not only provides the best supplier of the manufacturer but also provides conditions of establishing factories.

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Part V
Operations Research

A Hybrid Heuristic for Multi-shop Car Sequencing Problem with a Buffer

Yong-yi Wu and Hai-ping zhu

Abstract Considering the paint shop and assembly shop of car manufacturing as a whole, a two-phase method is proposed to solve the multi-objective car sequencing problem which consists of both shops with a buffer. Firstly, we minimize the objective in the paint shop and pre-optimize the objective of the assembly shop based on a multi-objective evolutionary algorithm, local search and crossover operator based greedy approach are designed for either objective. Secondly, the buffer adjusts the car sequence again by mixed heuristic. Simulation experiments are performed and the results show the effectiveness of the method.

Keywords Buffer • Car sequencing problem • Multi-object evolutionary algorithm • Pareto

1 Introduction

Car sequencing problem has been widely studied since car makers began to use mixed-model production line in car manufacturing. Researchers mostly focus on assembly shop objective where stakes are very high for the automobile industry [1], for example, the objective minimizing the difference of the consuming rates of different options described by Toyota is widely studied [2, 3].

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Furthermore, people came to concern more objectives in the sequencing problem as RENULT proposed the problem concerning not only assembly shop objectives but also paint shop objectives [4]. Celso C. Ribeiro solved this problem approximately by a set of heuristics [5], based on the paradigms of the VNS and ILS meta-heuristics, while Matthias Prandtstette solved it by linear programming approach and hybrid variable neighborhood search [6]. Some other algorithms could also solve this problem, such as local search, greedy approach and ACO [7–10]. However, these methods solve the problem as mono-objective by weighting different objectives linearly. Recently, researches of multi-objective have been done by concerning 2 or more objectives individually in an algorithm solving the car sequencing problem [11–13].

In this paper, we propose a two-phase method to solve the multi-objective car sequencing problem concerning objectives of two shops with a buffer, which is to optimize both objectives in the paint shop sequence and optimize the other shop's objective again by the buffer, while the final result would be a Pareto optimum consists of two car production sequences in either shop and a scheduling strategy of the buffer.

2 Problem Formulation

2.1 Paint Shop Objective

In the paint shop, painting equipment must be cleaned when changing the color of cars, which would lead to the increase of environment pollution and the decrease of production efficiency. So, we consider the frequency of switching car color as the objective of paint shop. The mathematical model of the objective g can be formulated as: $g = \min \sum_{n=1}^{N=1} S\,(D_n, D_{n+1})$, where n is the sequence number of a car, D_n is the color of car n, and the $S\,(D_n, D_{n+1}) = \begin{cases} 1, D_n \neq D_{n+1} \\ 0, D_n = D_{n+1} \end{cases}$ means the switch between car n and car n + 1.

2.2 Assembly Shop Objective

To consider the assembly shop objective, we use one function described by Toyota mentioned above. This function represents the sum of squared differences between the real consumption of an option and its ideal consumption rate for each option and for each vehicle. The mathematical model of the objective f can be formulated as

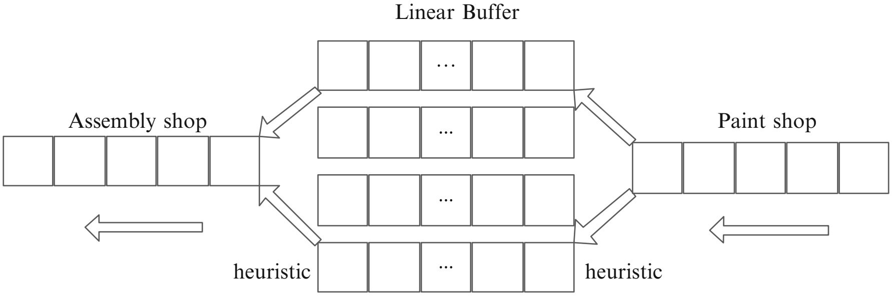

Fig. 1 structure of the buffer

$f = \min \sum_{n=1}^{N} \sum_{k=1}^{K} (n\alpha_k - \beta_{n,k})^2$, where n is the sequence number of a car, k is the type of car options, while $\alpha_k = \frac{1}{N}\sum_{n=1}^{N} n_k$ is the ideal consumption rate of option k which means the average consumption rate of the whole sequence, and $\beta_{n,k}$ is the real consumption rate of option k in car 1 to car n.

2.3 *Structure of the Buffer*

The buffer is set between the two shops in order to make the assembly line smoother, while it could also adjust the sequence which is going into the assembly shop. The structure of the buffer is like Fig. 1. The buffer is constructed by a sort of first-in-first-out channel and the scheduling strategy would choose one of them to get a car in or out.

3 Optimization Algorithms

3.1 *Multi-objective Evolutionary Algorithm*

The objective of this car sequencing problem is to get a sequence minimizing f and g, so we use the Non-dominated Sorting Genetic Algorithm(NSGA-II) to get a Pareto set which consists of (f, g) [14, 15]. Figure 2 shows the algorithm searching the Pareto set.

1. *Generation of initial solutions.*

   The initial solutions are randomly sequenced.

Fig. 2 NSGA-II

Input:
T maximum number of iterations
t_s number of iterations to switch the crossover operator
l length of crossover P_l probability of local search
P_m probability of mutation

Output:
PPareto set consists of value f, g and the corresponding sequence S

Initialize population by random sequence;
while $t<T$
calculate every f, g;
fast Non-dominated Sorting, calculate the dominance of every individual and the smallest ones survive as the offspring population
do local search by $P_{m;}$
if $t<t_s$
Crossover by greedy approach;
else Order based crossover;
do mutation by $P_{m;}$
end
return P;

2. *Fast non-dominated sorting.*

Calculate the value f and g of every individual after decoding, and distribute then into different levels by fast non-dominated sorting. Supposing the population as P, and p is the individual in P, calculate n_p and S_p of every individual, while n_p is the total number of who dominate p and S_p means the set of whom is dominated by p. Considering that there may be the same individuals in the population, we leave one of them and set the dominance of the others as $2\,N-1$ in order to clean them out of the population in the selection.

Figure 3 shows the procedure of fast non-dominated sorting.

3. *Selection of surviving population*

Put the generation $N-1$ and N together, then choose the best N individuals.

4. *Local search*

Considering that in the production sequence there may be cars with the same type or color, we exchange the location of two cars who have the same color which would not change the value of g while may change the value of f.

In order to get ones who have smaller value of f, we change the location of cars with the same color one by one, if the value of f gets smaller, replace the individual

Fig. 3 fast non-dominated sorting

```
while p ∈ P
 while l ∈ P
  if p dominate l
      S_p = S_p ∪ {l};
   else if l dominate p
    n_p = n_p + 1;
   if n_p = 0
    F_l = F_l ∪ {p};
i=1;
while F_i ≠ Φ
   while p ∈ F_i;
     while l ∈ S_p;
        n_l = n_l − 1;
        if n_l = 0;
         H = H ∪ {l};
   i = i + 1;
    F_i = H;
return F_i
```

by the new one, or make the next exchange until all cars with the same color have been exchanged.

5. *Crossover operator*

For the sequence which consists of n cars, now the parents' chromosomes are like: $x_1 = (r_{11}, r_{12}, r_{13}, \ldots, r_{1n})$, $x_2 = (r_{21}, r_{22}, r_{23}, \ldots, r_{2n})$.

The main purpose of genetic cross is to pass from parents to children superior genes as many as possible. We treat the chromosomes mentioned above as a ring (e.g. the car comes after r_{1n} is $r_{1n+1} = r_{11}$), as the main purpose of genetic cross is to pass from parents to children superior genes as many as possible, we can take advantage of greedy algorithm and implement genetic cross by the following procedure:

Assuming the target car is $r_{1c} = r_{11}$, we can find $r_{2k} = r_{1c}$ from the vector x2, and insert r_{1c} into offspring generation:

(1) If neither r_{1c+1} nor r_{2k+1} is in the offspring generation, we compare d (r_{1c}, r_{1c+1}) with d (r_{2k}, r_{2K+1}). If d $(r_{1c}, r_{1c+1}) >$ d (r_{2k}, r_{2K+1}), we set target car as $r_{1c} = r_{2k+1}$, otherwise we set target car as $r_{1c} = r_{1c+1}$. (As for the definition of d (i,j), if the car I and the car j have the same color, d (i,j) = 0, otherwise d (i, j)) = 1;
(2) Find $r_{2k} = r_{1c}$ from vector x_2, and add r_{1c} into offspring generation;
(3) In step 2, if one of the cars compared exists in offspring generation, we set the other as the target car, set $r_{1c} = r_{2k+1}$ or $r_{1c} = r_{1c+1}$, if both of the them exist in offspring generation, we compare the ones after them in their parents' chromosome which are $d(r_{1c}, r_{1c+2})$ and $d(r_{2k}, r_{2k+2})$ and so on.
(4) Repeat step 2 iteratively until we complete the offspring generation.

6. *Mutation operator*

   Randomly exchange the location of two random cars by P_m.

3.2 Hybrid Heuristics of the Buffer

This kind of buffer has a limited ability to adjust the sequence by choosing an appropriate channel when a car gets in or out of it. Both of heuristic rules and meta-heuristics could be used in controlling inbound and outbound cars. As the objective function is quite complex and the heuristic is difficult to construct, we adopt genetic algorithm to adjust the sequence outbound while using a sort of heuristic rules to control the inbound cars.

We use heuristic rule as our strategy of entering the station. The cases below are in a decreasing order of priority.

1. If a car entering station is of the same type as another car waiting at the end of a channel, it will enter exactly the same one;
2. Otherwise if it fails to find a channel falling into case one, a car will enter an empty channel;
3. Under the scenario neither case 1 nor case 2 fits, a car will enter the channel with fewest cars.

The genetic algorithm goes with doing the order based crossover operation, randomly exchanging the location of two random cars as mutation operator and selecting offspring populations by roulette wheel.

4 Numerical Experiment and Result

In order to prove the practicability and effectiveness of the strategy solving this car sequencing problem, we use Matlab 7 to test our algorithm in window 7, 2.26GHz, 2G M. we use the benchmark data provided by Toyota mentioned above so that we can make comparison.

4.1 Result of NSGA-II

The set of cars have 4 kind of colors, we call them b(black), g(grey), r(red) and w(white) and Table 1 shows the colors and options of the car sequence. The set of parameters is: $T = 100$, $N = 30$, $pm = 0.1$, $l = 7$, $Pl = 0.05$, $t_s = 30$.

The final Pareto set of this algorithm has three solutions: (3, 4029), (4, 3162) and (6, 2860).

Table 1 Data of the instance

		Type and number of the options										Color			
Type	Number	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	Black	Grey	Red	White
A	5	0	17	9	0	4	0	0	18	0	0	3	2	0	0
B	2	12	13	0	11	0	0	0	1	17	17	0	0	1	1
C	3	2	4	0	19	0	12	6	4	9	3	2	1	0	0
D	3	0	15	0	19	0	15	9	9	0	6	1	0	1	1
E	3	0	0	5	7	8	10	4	0	0	0	0	0	1	2

Table 2 Comparison of algorithms

Algorithms	Best result	
Goal chasing [2]	3,293	20.6 %
Genetic algorithm [2]	3,073	7.4 %
Simulating annealing [2]	3,162	15.1 %
Hybrid PSO [3]	2,860	0
NSGA-II	2,860	0

Table 3 Result of the buffer

Solutions	f after buffer	Improvement
(3,4029)	2,860	40.9 %
(4,3162)	2,860	10.5 %
(6,2860)	2,860	0

The solution (3, 4029) reaches the minimum value of the times of color switch while the corresponding sequence is Cg-Ag-Ag-Dw-Ew-Bw-Dw-Db-Ab-Cb-Ab-Cb-Ab-Br-Er-Dr, and the solution (6, 2860) reaches the minimum value of f while the corresponding sequence is Cg-Ag-Dr-Er-Br-Ag-Dw-Ew-Ab-Cb-Ab-Bw-Eb-Db-Ab-Cb. Table 2 shows the comparison of the result by different algorithms.

4.2 *Result of Buffer Scheduling*

The capacity of the buffer is 4*4, and the parameter of the genetic algorithm is: $T = 100, N = 50, pc = 0.8, pm = 0.1, l = 6$. After the scheduling of the buffer, all of the 3 solutions reached the minimum value of f. Table 3 shows the improvement on value f.

The solution of (3,4029) reach the minimum of both objectives, and the corresponding sequence is Cg-Ag-Dw-Ew-Bw-Ag-Db-Ew-Ab-Cb-Ab-Br-Er-Dr-Ab-Cb, while the sequence in the buffer is:

1. Cb-Cb-Bw-Cg;
2. Ab-Ab-Ag-Ag;
3. Er-Ab-Db-Dw;
4. Dr-Br-Ew-Ew.

5 Conclusion

This paper presents a hybrid two-phase strategy solving the multi-objective car sequencing problem with a buffer. The algorithm of NSGA-II can get a smooth Pareto front while the buffer can optimize the objective in the assembly shop effectively. Compute can be done in 4 s which could fit the industry environment well.

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(τ, L) Maintenance Policy of Cold-Standby System Under Reliability Constraints

Zhi-yong Hu, Li-yang Xie, and Xiang-wei Kong

Abstract In the view of maintenance plan, the work cycle is divided into two periods, namely normal maintenance period and idle period. During the normal maintenance period, the using unit isn't maintained or replaced until it fails or PM time arrives. If the acting unit work time come idle period from normal maintenance period, the reliability requirement of acting unit is reduced. Acting unit work until it fails or its maximum permitted life arrives, then it is idle until overhaul time arrive. A numerical sample is illustrated and its process of work cycle is simulated by Monte Carle Simulation. It is concluded that the two stages maintenance policy in work cycle cuts down the maintenance times at the same time assures reliability level.

Keywords Cold-standby system • Idle period • Preventive maintenance • Reliability

1 Introduction

Complex system, for example aircraft or space station, need high reliability and is used to utilize redundancy in order to realize reliability requirement for them. Standby redundancy systems mainly can is divided into cold standby, warm standby and hot standby. The using unit and standby unit in hot standby bear same load and is resultant to have same hazard rate, whereupon hot standby unit is treated as parallel unit. An increasing interest in the development of highly reliable systems

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has probably been a significant reason for the extensive treatment of reliability models for k-out-of-n: G systems in the literature [1]. The k-out-of-n: G model has wide applications in engineering systems [2].

A more formal statement is: The reliability of 'a system of mutually s-independent components which has been enhanced by 1 *parallel* redundant component on each of its components' exceeds at any point in time t the reliability achieved by creating '1 *parallel* redundant duplicate system on the original system' [3, 4]. Myron applied Boole's inequality to result in a simple lower bound for subsystem reliability in terms of reliabilities of subsystem for a k-out-of-n: G system [5]. Akhtar modeled the system behavior with Markov chain, used a recursive approach to evaluate reliability, availability, MTTF, and MTTR of k-out-of-n: G repairable system [6]. Kullstam showed the availability, MTBF and MTTR results of repairable redundant m-out-of-n: G system by the knowledge of the probability P_k (t) [7]. Newton commented on [7] and used the alternative probability argument to obtain the MTBF and MTTF for such system [8]. Barlow and Heidtmann presented a simple, exact linear-time algorithm which was in form of f BASIC program for calculating the reliability of a k-out-of-n: G system [9].

A common method of achieving high system availability for critical environments is subsystem redundancy. As the required availability of k-out-of-n: G system increases, the cost does increase due to the increase in the required number of spare subsystems. Srivastava and Fahim reported two important enhancements to an integer simplicial optimization method for spare allocation problem where it is required to minimize spare cost of a k-out-of-n: G system configuration subject to an availability constraint [10].

Flynn, Chung and Chiang studied a discrete time, infinite horizon; dynamic programming modeled for the replacement of component in a coherent system and justified critical component policies (CCP), via, a policy specified by a critical component set and the rule [11]. Chung and Flynn studied a discrete time, infinite horizon, dynamic programming model for the replacement of components in a binary k-out-of-n: F system with s-independent components and traded off the component replacement and system failure costs by following the CCP [12].

Barlow and Hunter defined two types of preventive maintenance policies, viz, Policy I was defined as follows: perform preventive maintenance after certain time of continuing operation without failure and policy II was defined as follows: perform preventive maintenance on system after it has been operating a total of certain time regardless of the number of intervening failures [13]. Policy I is named age replacement policy (ARP). Under which items are replaced at constant intervals of time and at failure, is wasteful because sometimes almost new items are also replaced. Block replacement policy, under which items are replaced at constant intervals of time and at failure [14]. Tango suggested extended block replacement policy (EBRP) under which: (1) items are exchanged for new items at time $kT(k = 1, 2, \ldots)$; (2) if items fail in $[(k-1)T,\ kT-\upsilon)$, they are replaced by new items, but if they fail in $[(k-1)T,\ kT)$, they are replaced by used items, where $0 \le \upsilon \le T$. The policy II in [13] is named block replacement policy (BRP) [15]. A well know preventive replacement policy was the block replacement policy (BRP) in which the item undergoes a planned replacement at a sequence of equally spaced time points independent of failure history and if there is more than one item the planned replacement times are common for all of them [15]. Berg and Epstein presented a different modification of the basic BRP which was called a modified BRP (MBRP) [15]. In the MBRP, failed items is replaced instantaneously after failure, but items possessing age $b(0 \le b \le t)$ or less at scheduled block replacement points $t, 2t, 3t, \ldots$ are not replaced by new items but are instead permitted to remain in service. Nakagawa considered a modified block replacement policy in which a unit is replaced at failure during $(0, T_0]$ and at scheduled replacement time T, and if a failure occurs in an interval (T_0, T), then the unit remains as it is until T [16]. Park and Yoo proposed a new BRP a group of nominally identical units. Under the BRP, a block replacement is performed at failure k, counting after the predetermined individual failure-replacement interval $(0, \tau]$ [17]. This 2-phase policy is called Block Replacement policy based on Idle Count which is abbreviated as BRIC (τ, k).

Pham and Wang studied the opportunistic maintenance of a k-out-of-n: G system with imperfect preventive maintenance (PM) where partial failure is allowed [18]. Two $(\tau\ T)$ opportunistic maintenance models with the consideration of reliability requirements were proposed. In these two models, only minimal repairs are performed on failed components before time τ and the corrective maintenance (CM) of all failed components are combined with PM of all functioning but deteriorated components after τ; if the system survives to time T without perfect maintenance, it will be subject to PM at time T. Park and Pham developed a generalized block replacement model (GBRP) for a k-out-of-n system and determined the optimum policies of both the threshold level for the number of failed components to prevent system failures and the maintenance cycle that minimizes the expected total system cost. Let m denote the threshold level [19]. If there are less than m numbers of failures in the maintenance cycle, then the failure replacement (FR) services for failed units and the preventive replacement (PR) services for other deteriorating units will be provided at the end of the periodic time. If there are m numbers of failures, then the FR services will be provided immediately at that point for failed components only and the PR services are not provided for other deteriorating components. The second term on the right hand isn't reasonable because the virtual life of unit at t is less t if the unit has suffered FR and equal t if the unit hasn't suffered FR.

2 2-Phase Policy of Cold-Standby System Under Reliability Constraints

In the process industries, such as metallurgy industry, the petrochemical industry, pharmacy and Coal-fired power plant, centrifugal fan affect straightway the efficiency, safe, operation of equipment system whereas isn't critical procedure equipment. In practical operation, some subsystems as fan system in equipments of industries which are mentioned above realize the capacity requirement by parallel units. At the same time, using redundancy promotes these subsystems reliability in operation period or overhaul interval. Therefore to determine maintenance plan has to consider the failure rate and failure effect which can be transformed reliability constraint. For redundancy system, considering the function of standby unit that promotes the subsystem reliability in operation period is reasonable to determine the maintenance plan to avoid over maintenance.

We present new maintenance policy under which the operation period is divided into two phases and different phase takes different maintenance policy. Assumed L denoted the operation which is divided into former phase and later phase, t falling in $[0, L-\tau]$ belongs to former phase and t falling in $(L-\tau, L]$ belongs to former phase. In the operation period there is reliability bound on the acting unit considering the safe requirement and failure effect, in the former phase there is a reliability requirement ζ_1 and in the former phase there is a reliability requirement ζ_2. Under above requirement, in the former phase the acting unit is maintenance instantaneously after it fail or when the PM time which is determined by ζ_1 arrives, the maintenance is perfect and the unit is as good as new after maintenance; in the later phase the acting unit is idle after it fail or when the PM time which is determined by ζ_2 arrives. This 2-phase policy with different reliability constrains is called (τ, L) maintenance policy of cold-standby system under reliability constraints.

In a lignite chemical process system which lies in the Inner Mongolia Autonomous Region of P.R.C, centrifugal fan is used to blow the hot smoke which is produced by pulverized coal powder burning in pulverized coal fired boiler. For promoting the reliability of fan system redundancy is adopted and there are six parallel sets of fan in fan system which consists of three sets of fan as acting unit and three sets of fan as cold-standby unit.

3 Numerical Example

In a lignite chemical process system which lies in the Inner Mongolia Autonomous Region of P.R.C, centrifugal fan is used to blow the hot smoke which is produced by pulverized coal powder burning in pulverized coal fired boiler. For promoting the reliability of fan system redundancy is adopted and there are six parallel sets of fan in fan system which consists of three sets of fan as acting unit and three sets of fan as cold-standby unit. The life of bearing under the condition follows Weibull distribution. The failure rate function of Weibull is $\lambda = \beta\theta^{-\beta}\,(t-\alpha)^{\beta-1}$. The value of β and θ and α is 4 and 500 and 50 respectively. The operation period is L whose value is 4,320 h. Synthetically considering maintenance cost and failure effect, the value of ζ_1 and ζ_2 is chose to be 0.995 and 0.99 respectively. The PM interval T when the reliability is ζ_1 is 284 and the permitted maximum age T^* when the reliability is ζ_2 is 309. The reliability of operation period of fan system is calculated by Monte Carlo simulation which is iterated 10^5 times. The outcomes of simulation are listed in Table 1.

Table 1 The reliabilities of fan system in operation period with τ values

τ(h)	R(%)	τ(h)	R(%)	τ(h)	R(%)
240	100	290	100	340	100
250	100	300	100	344	100
260	100	310	100	345	0.34
270	100	320	100	350	0.17
280	100	330	100	360	0.09

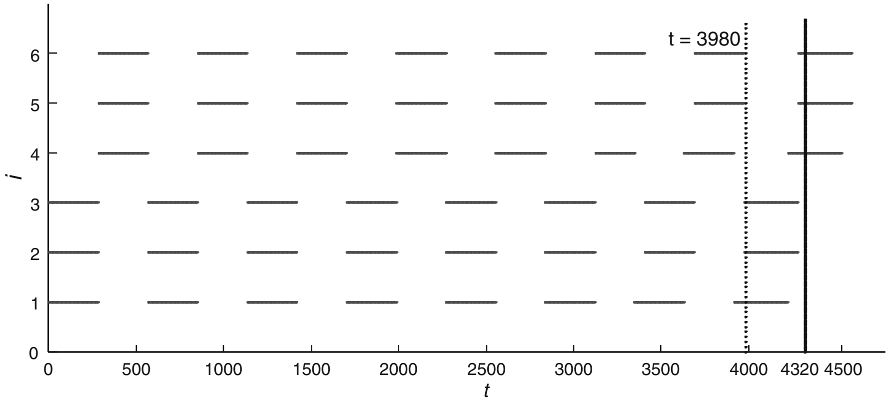

Fig. 1 The states of fans at t with $\tau = 344$

It is showed fan system reliability in operation period is sensible to τ value by Table 1. The value of reliability of fan system in operation period is 1 with the value of τ is 344. Oppositely the value of reliability of fan system in operation period is 0 with the value of τ is 345. When $\tau = 344$, the states of fans is showed in Fig. 1. When $\tau = 345$, the states of fans is showed in Fig. 2. The last shutoff time of No.4 fan and No.5 fan and No.6 fan is $t = 4{,}320$ when all fans are replaced and isn't $t = 4{,}595$.

The last shutoff time of No.4 fan and No.5 fan and No.6 fan is $t = 4{,}595$ in Fig. 1, which means that No.4 fan and No.5 fan and No.6 fan can operate until $t = 4{,}595$ when the reliability of them is ζ_2.

The scheduler time points at that fan are started up under maintenance policy are listed in Fig. 3 if the value of τ is equal or less than 344.

The scheduler time points at that fan are shut off under maintenance policy are listed in Fig. 4 if the value of τ is equal to or less than 344.

The value of L minus τ is 3,976 when $\tau = 344$. The following analysis is done under $\tau = 344$. No.4 fan and No.5 fan and No.6 fan are shutoff after executing 7th operation and No.1 fan and No.2 fan and No.3 fan are start up for 8th execution instantaneously at $t = 3{,}976$. No.1 fan and No.2 fan and No.3 fan are shutoff after executing 8th operation and No.4 fan and No.5 fan and No.6 fan are start up for 8th execution instantaneously at $t = 4{,}285$. No.4 fan and No. 5 fan and No.6 fan are shutoff after executing 8th operation at $t = 4{,}320$. All of fan are replaced at $t = 4{,}320$.

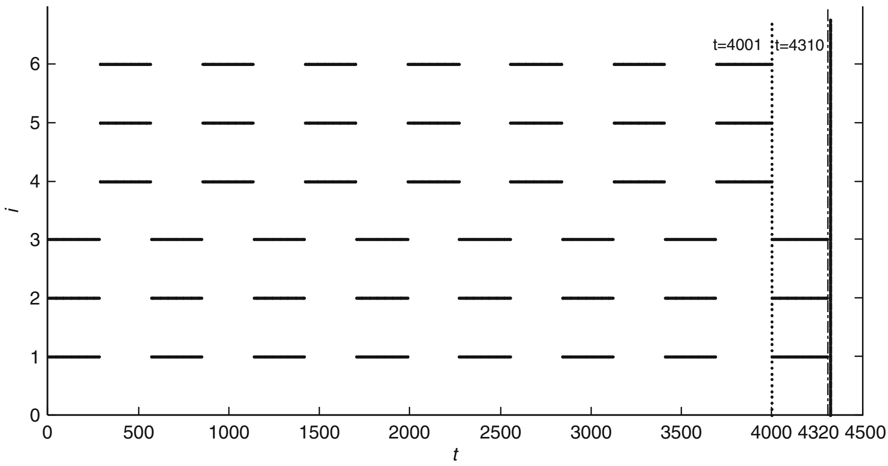

Fig. 2 The state of fan at t with $\tau = 345$

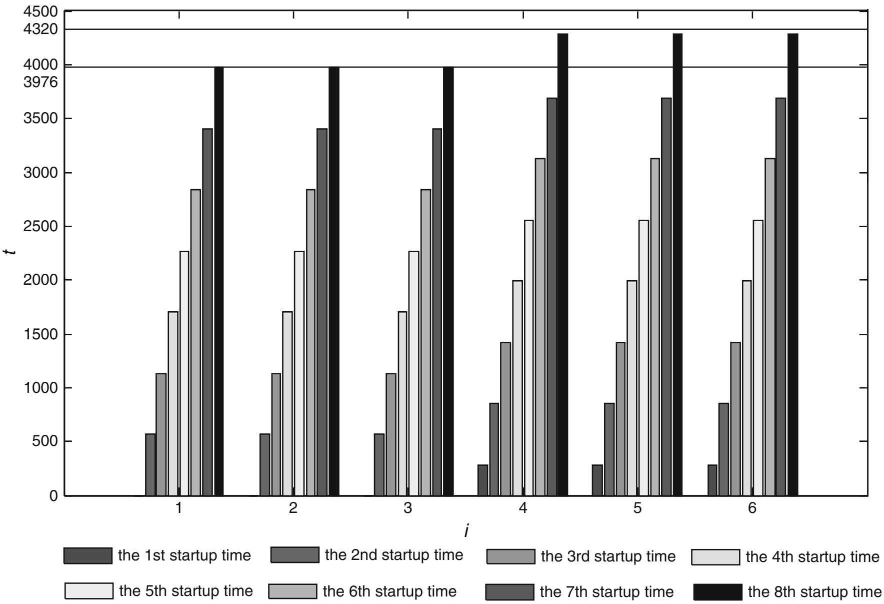

Fig. 3 The startup time of fan with $\tau = 344$

The following analysis is done under $\tau = 345$. The value of L minus τ is 3,975 when $\tau = 345$. No.4 fan and No.5 fan and No.6 fan are shutoff after executing 7th operation at $t = 4{,}001$ and are idle until $t = 4{,}320$. No.1 fan and No.2 fan and No.3 fan are start up for 8th execution instantaneously at $t = 4{,}001$ and are shutoff after executing 8th operation at $t = 4{,}310$. The fan system is fail because there are zero sets of idle fan, which leads to the process shutting up.

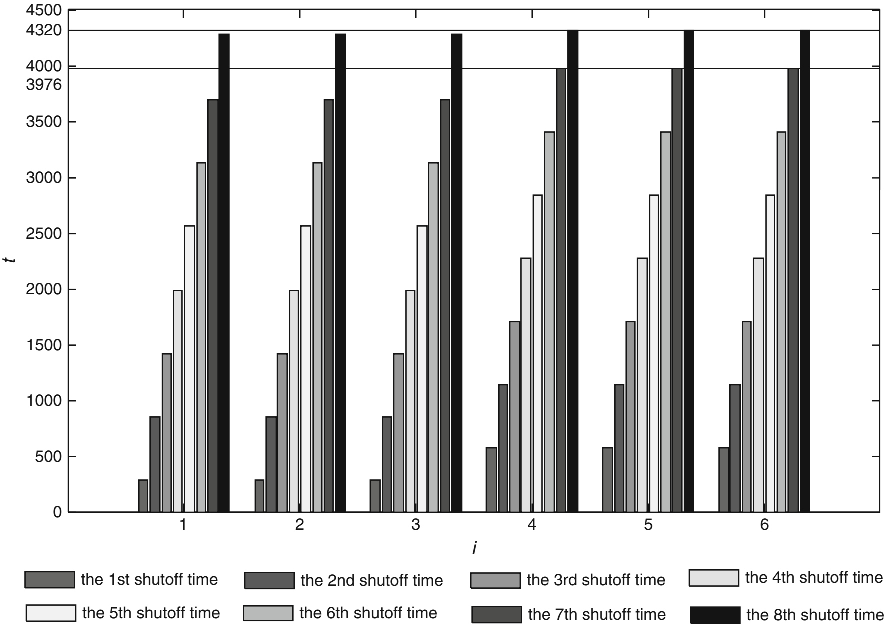

Fig. 4 The shutoff time of fan with τ = 344

4 Discussion

If τ = 0, the number of PM equal 16 = ceil [L/T] where function ceil(x) in Matlab generates an integer which is equal to or big than x. The various outcomes with various values of τ are listed in Table 2. The τ_1 denotes the maximum value of τ which assured the reliability equal 1 in operation period under maintenance policy and the N_1 denotes the total PM number when $\tau = \tau_1$. The τ_0 denotes the minimum value of τ which leads the reliability equaling 0 in operation period under maintenance policy and the N_0 denotes the total PM number when $\tau = \tau_0$.

Assumed the last startup set of acting fans in operation period operate until if fail or the overhaul point when $\tau = \tau_0$. Under the assumption, the T_{max} denotes the maximum life of the last startup set of acting fans and the approximately reliability is denoted by R_{min}.

5 Conclusion

We developed a 2-phase PM policy for a redundancy system with cold-standby units. The later phase of operation period is named idle period. The acting unit will not be taken maintenance and be idle after it fail in idle period or its age arrives T* at idle period, which can eliminate none effective maintenance but doesn't affect the system reliability in operation period.

Table 2 The various outcomes with various τ and different determination parameters

ζ_1	ζ_2	T	T*	τ_1	τ_0	$\tau_0 - \tau_1$
0.99999	0.995	179	284	382	562	180
0.995	0.99	284	309	344	345	1
0.995	0.95	284	389	344	629	285
0.995	0.90	284	435	344	629	285
ζ_1	ζ_2	N	N_1	N_0	T_{max}	R_{min}
0.99999	0.995	75	66	60	456	0.66
0.995	0.99	48	42	39	319	0.96
0.995	0.95	48	42	39	523	0.40
0.995	0.90	48	42	39	520	0.41

The value of τ is critical to divide the operation period into two phases. As simulation outcome of the numerical example show, the bigger value of τ which leads the maintenance number has a decrement which equals the number of acting fans comparing the number with smaller value of τ, at the cost of the dramatic decrement on system reliability in operation period than of the smaller value of τ.

The 2-phase different maintenance policy is fit for the parallel system and *k*-out-of-*n*: G system and warm-standby system. It is different from cold-standby system, the standby unit in warm-standby system and hot-standby system (*k*-out-of-*n*: G system) suffers load and has failure risk.

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Shifts from Collectivism to Individualism in Multinational Organization Context (in Mainland China)

Ming-fei Li and Aliaksandr Palavinchykau

Abstract While elaborating a certain HR activity in a foreign MNC subsidiary, we should take into an account the fact whether a person or a team is individualistic or collectivistic.

Individualism (IND) – Collectivism (COL) is an important dyad to study because individualists and collectivists have different preferences for the way of working, the reward system, and the ways of solving the conflict. But analyzing the dimension of IND-COL, it is important to take into account possible shifts from COL toward IND because cultural values are assumed to develop over time after repeated exposure to multiple facets of culture.

The aim of this paper is to explain how shifts from COL to IND are reflected in Multinational Organization Context in Mainland China as well as how shifts from COL to IND are reflected in values and attitudes of Chinese working for foreign companies.

Keywords Collectivism • Individualism • MNC • Main-land China • Organizational context

1 Introduction

While elaborating a certain HR activity in a foreign MNC subsidiary, we should take into an account the fact whether a person or a team is individualistic or collectivistic.

Individualism (IND) is defined as "a loosely knit social framework in which people are supposed to take care of themselves and of their immediate families only", while collectivism (COL) "is characterized by a tight social framework

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in which people distinguish between in-groups and out-groups, they expect their in-group to look after them, and in exchange for that they feel they owe absolute loyalty to it" [1].

IND – COL is an important dyad to study because individualists and collectivists have different preferences for:

- the way of working (working alone (IND) vs working in groups (COL));
- the reward system (equity principle (IND) vs equality principle (COL));
- the ways of solving the conflict (sticking to the personal experience and training (IND) vs sticking to the rules and norms (COL)).

But analyzing the dimension of IND-COL it is important to take into account possible shifts from COL toward IND [2] because cultural values are assumed to develop over time after repeated exposure to multiple facets of culture(s) [3, 4].

It is commonly assumed that cultures emanating from countries such as China and other Eastern Asian countries would be more likely to exhibit features common to collectivist societies [1, 3]. While this assumption may have been supported in the past, it is plausible that as China experiences rapid economic growth and progresses as an industrialized nation, its culture, according to the modernization theory, will be under environmental pressure to become more individualistic in nature.

Speaking further about shifts from COL to IND, we can mention the research made by Ralston et al. (1999), who tested the managerial value of the new generation managers in China. The research compared the values of old generation and new generation managers, and the result showed that Chinese managers are becoming more individualistic, less collectivistic, and lower in Confucian dynamism [5].

What are the reasons for this phenomenon?

With the implementation of the economic reforms and embracing of the market economic approach, Western culture to some extent has been instilled to almost every Chinese. Consequently, Western values like materialism and IND have become the dominant ones among Chinese people, especially the younger generations including the new generation leaders [6].

The cultural tendency toward IND has also been accelerated due to China's one-child policy which creates more self-centered new generation leaders.

So it seems to be a big question whether China still remains a collectivistic nation.

Speaking about Multinational Organization Context in Mainland China, shifts from COL to IND seem to be even more evident. Chinese working for international companies can be greatly influenced by the characteristics of this context, that is: the ideas of gender equality, achievement motivation, independence, greater civic participation, greater social relationships beyond kin, distancing from tradition and religion as a source of authority and some other psychological consequences of societal modernization [7, 8].

Taking into account the above mentioned, we can also suppose that under the influence of Multinational Organization Context in Mainland China Chinese can start to change their attitudes to the way of working (prefer working alone to working in groups), the reward system (prefer equity principle to equality principle) and the ways of solving the conflict (prefer sticking to the personal experience and training to sticking to the rules and norms) – that means, can become more individualistic.

The aim of this paper is to explain how shifts from COL to IND are reflected in Multinational Organization Context in Mainland China as well as how shifts from COL to IND are reflected in values and attitudes of Chinese working for foreign companies.

The companies in question are foreign MNCs' subsidiaries in Mainland China; the subjects are Chinese nationals working for these subsidiaries.

2 Literature Review

2.1 Individualism and Collectivism in Organizational Context

Over the years the dimension of IND and COL has become the most important in studying cultural differences, though the other Hofstede's dimensions (Power Distance, Uncertainty Avoidance, Masculinity – Femininity, Long-term – Short-term Orientation) also deserve attention [9].

IND is defined as "a loosely knit social framework in which people are supposed to take care of themselves and of their immediate families only", while COL "is characterized by a tight social framework in which people distinguish between ingroups and outgroups, they expect their ingroup to look after them, and in exchange for that they feel they owe absolute loyalty to it" [1].

In individualist cultures, studies found greater use of individualist HR practices. For example, people were selected on the basis of individual attributes, while in collectivist cultures they were selected on the basis of group memberships [9].

According to Triandis, there is more training in collectivist that in individualist cultures because employees are more loyal to the organization and high in organization commitment, so that they are less likely to leave the organization [9].

Speaking about the collectivists' loyalty and commitment to the organization they work for, we should point out, that in respect of modern China it seems not to be so.

As one Compensation and Benefit Advisor noticed, Chinese potential candidates are becoming more short-term benefit oriented and consequently how it will be increasingly challenging to transfer and implement in China effective remuneration policies [10].

Due to the short supply and high demand in the Chinese market of professionals, turnover here is extremely high. A survey's data also suggest that Asia-Pacific employees tend to be unhappy with their level of compensation and benefits [11].

A study, The Flight of Human Talent: Employee Retention in China 2006–2007 by Development Dimensions International (DDI) and the Society for Human

Resource Management (SHRM) suggests that turnover has become a way of life in China: 73 % of Chinese employees surveyed resigned from their last job in the past 12–18 months and 22 % are likely to leave within a year. And every year, 30–40 % of senior managers at MNCs change jobs, primarily due to lack of growth and development opportunities within the company or better career opportunities elsewhere.

As Helmut Hennig, Group Managing Director of Jebsen & Co Ltd noted their company's biggest problem is retaining staff. According to his words, the turnover in their organization constitutes 15 %. This is about average for the industry, but that means his company is mainly recruiting in order to replace lost staff, rather than to grow our business. And there is a huge loss in productivity as a result [12].

It is not uncommon for turnover in Chinese companies to approach 100 % per year [13]. Moreover, speaking about candidates, they not only change employers frequently but also demand extremely high salary increases [11].

So Chinese don't seem to be so loyal to their organizations.

What are the most importance means of making employees loyal?

Jeffrey, head of Unilever-Best Foods joint ventures in China, assumed that compensation was the most important thing to top managers at one JV. But after some tribulations, managers found that training and development was the first priority, followed by work environment, visible career path and compensation. "Work environment" was a combination of respect and leadership of the manager as well as office space [13].

Employees are less likely to leave if they have a good manager, recognition for individual contributions, opportunities for accomplishment and strong company leadership [14, 15].

In order to create employee engagement and to retain key talent, it is necessary for employers to provide clearly laid out career paths and provide employees with the tools to achieve their goals. Other methods of retention include increased exposure (to the business and HR functions) and responsibility [11].

Retention through a means of career development has proved to be one of the most effective methods.

Developing a company's "learning" system is also considered as one of the core policies to attract and retain top talents in the local Chinese market as a result of the high importance addressed from local Chinese to those issues [10].

Masayuki Kamiya, Senior Executive Officer of Asahi Glass Co. states how it is important to attract and retain the talented people. It is not only the matter of compensation. For very talented and ambitious people, he thinks, we need to communicate well and show them respective future prospects [12].

Frank Liao, General Manager of China Avery Dennison RBIS points out: "In general, even with wage rises, there is a shortage of labor. The newly employed staff of a multinational tends to be very young. Their wage level is important, but even more important is their development path, and so creating a well structured career trajectory is vital to retain staff [12].

As it has already been mentioned, a good manager is one of the pre-requisites to attain the goal of retaining employees. What is meant by a "good manager" in China?

First of all, paternalism should be mentioned in this respect.

Paternalism is a more common leadership style in collectivist than in individualist cultures. In fact, the boss is much more involved in the personal life of employees, knows much more about them, and does more helpful things on their behalf in collectivist than in individualist cultures [9].

Managers in collectivist cultures are not as concerned with performance as managers in individualist cultures are, but they are more concerned with interpersonal relationships than managers in individualist cultures are [9].

With the recent concern about deception in organizations around the world, it is interesting to note that the IND-COL dimension has some relevance.

Triandis found that people in VC cultures are likely to use deception if it helps their in-group. However, people who are vertical idiocentrics are also likely to use deception [9].

In this case competitiveness and the need to be "the best" seem to be the factors that increase the use of deception [9].

Speaking further about this law and ethic aspect, we should mention the findings of Ronkainen and Guerrero-Cusumano research (2001) who found that countries with higher COL, as well as PD, and UA had higher rates of intellectual property rights violations in data from 50 countries (using Hofstede's [3] country scores) [3, 16].

Speaking about conflict settlement, within collectivistic nations, disagreements were more frequently handled through reliance on rules rather than personal experience or training; the opposite was found for individualistic nations [17].

2.2 Impact of Individualism-Collectivism in Multinational Organization Context in Mainland China: Shifts to Individualism

Recently it has been proved that MNC subsidiary practices start to increasingly resemble their parent MNC practices. Furthermore, there is an increasing hybridization of subsidiary HRM practices [18].

At the same time, Pudelko and Harzing [19] discuss the existence of a dominance effect by which they mean that a subsidiary's HRM practices are shaped not by the subsidiary's host-country or the MNC home-country, but rather by the country that sets the standard for what is considered to be "global best practices". They suggest that there is a convergence around American practices and that these are generally considered "best practices" [18].

Therefore, taking into account that American HR practices are generally considered to be individualistic, we can suppose that:

Hypothesis 1: Shifts from Collectivism to Individualism among Chinese managers working for MNCs in Mainland China are positively associated with implementation of American HR practices.

New institutional theory assumes that the actions of organizations are not only a result of rational decision-making processes with the goal of maximizing effectiveness, but that they are also influenced by the social, institutional context in which the organization exists. This implies that organizations adopt certain structures and ways of operating in order to obtain legitimacy in their environment [20].

MNC subsidiaries exist under conditions of institutional duality – they are subject to (conflicting) institutional pressures both from their local host-country environment as well as from the internal MNC environment [18].

DiMaggio and Powell (1983) suggest that organizations adopt different practices through three different processes of isomorphism: coercive, mimetic, and normative [21].

Scott [22] has later termed these regulatory (coercive), cultural-cognitive (mimetic), and normative.

In the context of MNC subsidiaries an example of coercive isomorphism is when laws and regulations in the subsidiary's host country force the subsidiary to adopt certain HRM practices.

In this respect, the Chinese regulatory context for HRM has undergone significant changes during the last years. One of the main drivers behind the transition has been the move from a highly centralized allocation process to a more decentralized, market- and merit-based system. Although state intervention is still widespread in many facets of business, the Chinese approach to reforming the economy has nevertheless afforded MNCs considerable flexibility in how they recruit, develop and remunerate staff. Indeed, the free labor market that has been emerging in China has already had significant implications for staffing practices. In addition, the Chinese personnel and labor bureaus, which in the 1980s and early 1990s tried to influence HRM practices in foreign-owned units in PRC, by the mid-1990s, had begun to exert less influence [21].

Referring to the widely held social knowledge and belief about HRM, the cognitive institutional environment in PRC has been characterized by a historical absence of the Western HRM concept [21].

Traditionally, the personnel system was characterized by government-determined hiring quotas, egalitarian compensation practices, a narrow definition of employee training, and the "iron rice bowl" policy of lifetime employment [21]. By the mid-1990s, some parts of this system had been phased out while others remained, and by the beginning of the twenty-first century the HRM practices of leading MNCs like Nokia and Motorola were often hailed by the Chinese media as models to be followed by domestic firms. Although empirical evidence suggests that the HR function in Chinese organizations is failing to meet the performance expectations of line managers [23], and still tends to be strongly associated with administrative work and services [24], the longitudinal picture depicts a growing role for the HR function alongside a discontinuation of most traditional Chinese personnel practices in favor of more Western-style HRM practices [25].

Representing the values, beliefs and norms about human nature, the normative institutional context for HRM in PRC has received considerable research attention, most notably through the application of cross-cultural perspectives. For example, Huo and Von Glinow [26] argue that there are a number of Chinese cultural characteristics that render any integration of Western HRM practices problematic unless they are "culturally rational". These include the importance of saving face, respect for authority and non-direct verbal style. Other features mentioned in the literature are harmonious peer-subordinate relationships in performance appraisals, familism and guanxi in staffing practices [24], as well as increasingly a "cash mentality" in compensation preferences. For these reasons, Ding and Warner [27] argue that foreign subsidiaries are unlikely to exclusively adopt their parent HRM practices, but rather will utilize "hybrid" HRM systems that exhibit Chinese characteristics.

However, "cultural arguments" for local HRM practice differentiation have been criticized for over-essentializing culture in a way that it views it as static rather than "a shifting and changeable repertoire" with diverse strands" and in providing weak explanatory power regarding the specific origins of both global and local effects. When viewed in this way, societal values and behavioral norms held by Chinese citizens can be challenged and to some extent adapted when they are encouraged to practice Western-style HRM over a long period.

Further, in an era of globalization of industry, information, and people, cultural changes at the societal and other levels of analysis are likely to take place. Indeed, a recent study of managerial values systems related to business ideology showed that the values held by mainland Chinese managers had converged with those of Hong Kong and US managers from 1979 to 2001.

Shifts to more individualistic values, particularly amongst the younger generations of Chinese citizens are likely to have rendered arguments about the "cultural misfit" of Western HRM practices less convincing.

An example of internal coercive isomorphism could for instance be when the subsidiary is forced to adopt a certain practice by HQ due to HQ's authority or on account of its resource dependence on HQ [18].

Mimetic isomorphism leads organizations to model themselves on other organizations as a result of uncertainty in the environment. This means that MNC subsidiaries are likely to copy the practices of other similar organizations in their external environment (mostly MNCs) that appear to be successful. The diffusion of “best practice” within the MNC is an example of a process of internal mimetic isomorphism in that subsidiaries copy a practice that is viewed as useful within the organization [18].

Finally, normative isomorphism implies that professionals in the same field will develop similar norms and methods of work for, for example, due to receiving similar formal education or involvement in the same professional networks.

Drawing on institutional theory we can state that due to changing coercive, mimetic and normative isomorphic pressures in the Chinese environment there has been a shift from traditional Chinese personnel practices to more Western-style HRM practices [25].

According to Björkman et al. (2008), HRM practices in MNC subsidiaries in China have become increasingly similar to MNC home country practices [28].

In regard to the convergence with the practices of local Chinese companies the findings suggest that, on one hand, MNCs may be forced to adapt certain HRM practices, e.g. compensation, to the local Chinese context. For example, bonuses related to seniority status within the company as a result of Chinese cultural values and previous employment system highly valuing seniority [11].

On the other hand, MNCs can influence Chinese companies in their view of what is considered as appropriate HRM in the Chinese context [25]. This could be indicative of deinstitutionalization, which implies that existing organizational patterns erode or discontinue as a result of changes that influence what is considered legitimate. In this case it implies that MNC subsidiaries introduce new ways of doing things which gradually become internalized and taken for granted in their host-country context, thus challenging existing HRM in Chinese companies [18].

Chen and Wilson [29] argue that a focus solely on national context and culture neglects the impact of organizations and their management in the formation of HR policy and practice.

Taking this into account we can suppose that:

Hypothesis 2: Changes in organizational context are positively associated with company’s organization and management system, but not with cultural peculiarities such as Individualism-Collectivism.

Compensation was the practice that showed most evidence of convergence with local Chinese companies, followed by methods of recruitment [18].

An explanation for the significant convergence in compensation practices and recruitment methods can be the heightened war for talent precipitated by the increasingly open and competitive Chinese labor market for professionals and managers. Indeed, the reported difficulties in finding and retaining managers with the requisite business and linguistic skills has made it seemingly imperative for MNC subsidiaries to follow closely and adopt the visible recruitment and compensation practices of companies with whom they are competing for scarce talent [18].

At the same time, MNCs have been found to transfer consistent international performance appraisal policies [. . .] despite the existence of cultural diversity.

More detailed analyzes show that the changes are fairly unevenly distributed across HRM practices with training showing the clearest statistically significant shift towards increased parent resemblance. There is also some evidence of a similar trend for performance appraisal and recruitment. One possible explanation for the convergence in training is that the education and professional training of Chinese managers and professionals have improved considerably over the last decade. This, together with a significant increase in the number of people who have already gained considerable professional experience both in foreign-owned and local Chinese corporations, as well as a growing number of Chinese citizens returning from studies and careers overseas, have made the training needs in the Chinese units of MNCs more similar to those in other parts of the corporation. Additionally, it has been argued that investments in training and development are important ways for MNCs to retain well-performing employees in the competitive Chinese labor market [23], thus setting the stage for either transferring advanced management and professional training programs from MNC HQ or inviting subsidiary employees to take part in global programs [30].

Recent trends have shown that companies are no longer willing to pay exorbitant expatriate salaries and are focusing on a 'develop from within' strategy, or promote-from-within strategy [13].

A promote-from-within strategy is often more effective and less expensive than buying talent that is constantly turning over.

It is not enough to bring in expatriate leaders and attempt to transfer knowledge to locals. In fact, most companies are dissatisfied with the reliance on expatriate talent due to the associated high cost. In addition, expatriates may not be the most effective in transferring knowledge because of cultural differences. Companies must be willing to invest in developing talent through local training modules and seminars, rotational programs and international assignments.

Large MNCs often organize training programs locally and/or regionally for professionals and managers that to a large extent are based on programs designed centrally.

In connection with local adaptation, Tregaskis et al. [31] suggest that this is related to the greater transfer of systematic, "macro" training frameworks (e.g. methods used to identify training needs) and more local adaptation of "micro" HR development practices (e.g. tools used to develop an employee's career).

What concerns recruitment and selection practices, previous research has found the above mentioned practices were found to be more similar to those of local Chinese firms than were training and development, performance appraisal and compensation [23].

There are several arguments why recruitment and selection tend to be adapted to the local context.

Firstly, with the exception of very senior executives, external labor markets are predominately local in nature with a range of institutional factors influencing the supply of candidates [18].

Secondly, cross-national research has shown a number of variations in recruitment and selection practices viewed as appropriate in light of differences in national culture and social behaviors.

3 Conclusion

Analyzing the dimension of IND-COL, it is important to take into account possible shifts from COL toward IND [2] because cultural values are assumed to develop over time after repeated exposure to multiple facets of culture(s).

Due to the psychological consequences of modernization process such as personal efficacy, gender equality, achievement motivation, independence, greater civic participation, greater social relationships beyond kin, distancing from tradition and religion as a source of authority, and acceptance of social mobility [8], Chinese managers working for MNCs in Mainland China tend to be greatly exposed to shifts from Collectivism to Individualism.

The facts such as turnover has become a way of life in China, that Chinese potential candidates are becoming more short-term benefit oriented as well as tend to be unhappy with their level of compensation benefits [11] and some others can contribute greatly to the idea of shifts to Individualism among Chinese managers working for MNCs in Mainland China.

It's a well-known fact that young people are influenced to a large extent by any changes, especially if we speak about things such as globalization, modernization and shifts to Individualism. Taking into account that the newly employed staff of MNCs tend to be very young [12], then we can suppose that the young people in question may be influenced by the western HRM practices implemented in MNCs – that means, shifts to IND take place.

There are also some managerial implications in respect of the given issue. As individualists and collectivists have different preferences for the way of working, the reward system as well as the ways of solving the conflict, managers should take into account possible shifts to Individualism among Chinese employees and adjust their management and HR practices and policies according to the changes observed.

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Research on the Unbalanced Development of the Tourism Industry in Qinhuangdao

Gang-min Weng and Li-li Jia

Abstract This paper selects "benchmarking city" for Qinhuangdao from the six major coastal cities in Bohai Rim, based on the analysis of the spatial concentration of tourist flow. Then the comparison of the internal overall condition of the tourism industry of the two cities and analysis of the grey correlation between the internal factors and the tourism income are conducted. The result presents that the gap between Qinhuangdao and the "benchmarking city" is obvious, including infrastructures, tourism products, human resource and urban popularity. This paper puts forward unbalanced development approaches for Qinhuangdao in the fierce competition in Bohai Rim.

Keywords Grey relational analysis • Qinhuangdao tourism • Unbalanced development • Tourism management

1 Introduction

Since the 1970s, coastal tourism has attracted widespread attention due to its rapid development. The regional development trend of our country's coastal tourism makes the regional internal coastal cities compete fiercely. As a small-medium tourism city of Bohai Rim faced with the threaten from the city of Dalian, Huludao, Tianjin, Weihai, Yantai, Qingdao etc., Qinhuangdao has to seek an unbalanced development way and realize inclusiveness growth. Unbalance means city difference analysis and priority development putting the important resources into key parts.

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2 Methodology

Tourist areas of tourist destinations have attraction and concentration for tourist flow, so the size of the tourist flow proved to be the most direct and effective index to measure the level of the tourist destination. Spatial concentration index refers to proportion of the specific tourist area's tourist flow accounted for the total entry passenger flow in the same year. The spatial concentration index could be a measure of the attraction and concentration effects of the main tourist city in Bohai Rim [1–3]. It can be defined as

$$\alpha_i = \frac{\chi_i^t}{\sum_{i=1}^{n} \chi_i^t \times 100\,\%}$$

Where α_i is the spatial concentration index, α_i is the inbound tourists of i-th tourist area in year t. The smaller α_i is, the less obvious of the attraction and concentration effects of the tourist area is. It means the low tourist area level.

Correspondence analysis is a kind of multivariate statistical analysis method. Correspondence analysis is applied to the relation analysis of two categorical variables, while optimal scaling analysis mainly applied to three categorical variables [4, 5]. The optimal scaling analysis based on principal of data reduction, strives to visually show the relation between multiple variables and variable categories [6].

The grey relational analysis is an important content of the grey system theory, which measures the size of the correlation based on the trends and changes of the various factors in the system. Discrete form of system state variables is main objects of study [7]. The steps of grey relational analysis are as follows:

Determine the comparative sequence and the reference series

$$\begin{aligned} X_0 &= (\chi_0, \chi_1, \chi_2, \ldots, \chi_n)\,, \\ X_i &= (\chi_i(1), \chi_i(2), \ldots, \chi_i(n))\,; \end{aligned}$$

Where $i = 1, 2, \ldots, n$

1. Dimensionless

$$\begin{aligned} X_i' &= \frac{X_i}{\chi_i(1)} \\ &= \left(\chi_i'(1), \chi_i'(2), \ldots, \chi_i'(n)\right) \end{aligned}$$

Where $i = 1, 2, \ldots, n$

2. Solve difference sequence and find out the maximum and the minimum values

$$\begin{aligned} \Delta_i(k) &= \left|X_0'(k) - X_i'(k)\right|\,, \\ \Delta_i &= (\Delta_i(1), \Delta_i(2), \ldots, \Delta_i(k))\,; \end{aligned}$$

Where $i = 1, 2, \ldots, n$

'M' is the maximum value. 'm' is the minimum value.

3. Solve the correlation coefficient

$$\xi = \frac{m + \rho M}{\Delta_i(k) + \rho M}, \quad \rho \in (0, 1)$$

4. Solve grey correlation degree

$$\gamma_{ik} = \frac{1}{n}\sum_{i=1}^{n} \xi_{ik}(t).$$

3 Results

3.1 Unbalanced Comparisons of Spatial Concentration of Bohai Rim Coastal Tourist City Tourist Flow

This research selects six cities which are Tianjin, Qinhuangdao, Dalian, Qingdao, Yantai, Weihai as the objects of study. They locate along the Bohai coast with similar tourism resources and compete fiercely in tourism. Assumed that tourists have equal opportunity to choose their destinations in the six cities and the tourist flow is balanced. Spatial concentration index of each tourist area is about 16.7 %. The spatial concentration of inbound tourist flow is based on the number of inbound tourists. The recent years of spatial concentration index sees Table 1. The spatial concentration of domestic tourist flow is based on the number of domestic tourists. The recent years of spatial concentration index sees Table 2.

Table 1 The spatial concentration index of the inbound tourist flow of main cities in Bohai Rim

	Tianjin	Qinhuangdao	Dalian	Qingdao	Yantai	Weihai
2007	0.275346	0.059161	0.224054	0.288149	0.081993	0.071297
2008	0.321209	0.049297	0.250039	0.210902	0.092673	0.075880
2009	0.356214	0.056634	0.151609	0.252768	0.101267	0.081507
2010	0.332572	0.048514	0.233461	0.216342	0.094506	0.074604

Table 2 The spatial concentration index of the domestic tourist flow of main cities in Bohai Rim

	Tianjin	Qinhuangdao	Dalian	Qingdao	Yantai	Weihai
2007	0.362007	0.090833	0.149182	0.196042	0.120248	0.081689
2008	0.377527	0.066127	0.161705	0.182700	0.126453	0.085488
2009	0.290029	0.085815	0.178709	0.204447	0.144701	0.096299
2010	0.284067	0.086393	0.175390	0.204162	0.151913	0.098076

Table 3 The average spatial concentration index of the domestic tourist flow of main cities in Bohai Bay Basin

	Tianjin (%)	Qinhuangdao (%)	Dalian (%)	Qingdao (%)	Yantai (%)	Weihai (%)
The average spatial concentration index of the inbound tourist flow	32.1	5.3	21.5	24.2	9.3	7.6
The spatial concentration index of the domestic tourist flow	32.8	8.2	16.6	19.7	13.6	9.0

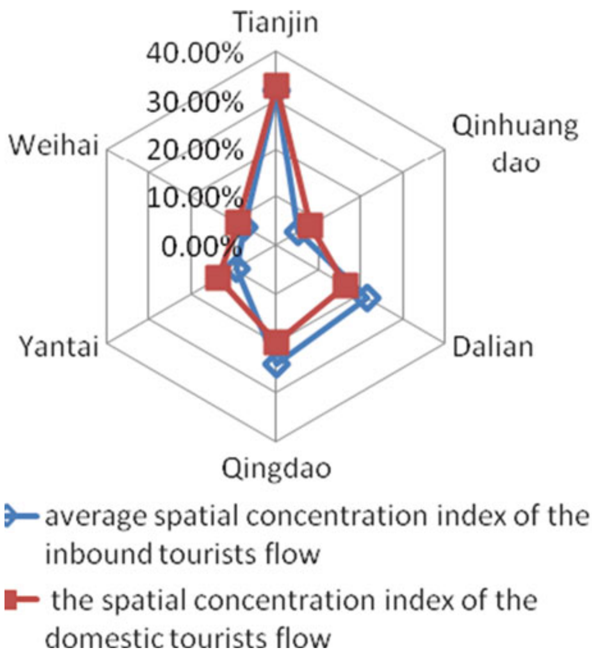
In order to eliminate the influence of changes in tourist number of different years, we choose the average of the recent years' spatial concentration indexes as the final result (see Table 3). According to the spatial concentration index of the six cities, the first level destination is set up when $\alpha_{\mathrm{i}} \geq 16.7$ % and the second level destination is set up when $\alpha_{\mathrm{i}} < 16.7$ %. According to the average inbound tourist flow spatial concentration index and the average domestic tourist flow spatial concentration index, such three cities including Tianjin, Qingdao and Dalian are evaluated as the first level destinations and the other three cities including Yantai, Weihai and Qinhuangdao are evaluated as the second level destinations. The spatial concentration index of the first level destination is far higher than the average, but the spatial concentration index of the second level destination is much lower than the average [8].

We can clearly see the differences between the six cities in Fig. 1 that the average spatial concentration index of Tianjin including inbound tourist flow and domestic tourists is the highest one, which means the concentration effect of Tianjin is the most obvious in the main cities of Bohai Rim. Qingdao, Dalian, Yantai, Weihai follow in turn. Qinhuangdao is also one of the first batch costal open cities and vice provincial national ecological landscape tourism cities, but its average spatial concentration index of tourist flow is the lowest. In order to make Qinhuangdao tourism develop well and gain competitive advantage, this paper introduces the benchmarking method pioneered by the Xerox in 1979, selects a coastal city whose tourism develop well in Bohai Rim as benchmarking, compares the differences and analyses the reasons [9]. Because Tianjin is not belong to tourist city of 3S for marine tourism resources is not its main part, we choose Qingdao as benchmarking city whose tourism resources are similar to that of Qinhuangdao.

3.2 Inner Relevance of Tourism Industry Based on Optimal Scaling Technique

In order to explore the inner elements' relationships of Qingdao and Qinhuangdao, we select the total output value of the tertiary industry, the average days to stay of

Fig. 1 Average spatial concentration index of six cities



inbound tourists, the number of inbound tourists, the number of inbound foreign tourists, foreign exchange earnings, the number of domestic tourists, the domestic tourism income, the number of star hotels, highway mileage, economic benefits of star hotels and catering industries, room income of star hotels and catering industries, meal income of star hotels, commodity income of star hotels and catering industries, the number of star hotels and catering companies, the number of employees in star hotels and catering industries as analysis variables. We apply the optimal scaling technique to the 15 analysis variables by SPSS18.0. The relationship between the two cities sees Fig. 2.

The infrastructure of Qingdao concluding highway mileage, the number of star hotels and the number of star hotels and catering companies has certain relationship with tourism development. The good infrastructure can promote the tourism development of a city. The number of employees in star hotels and catering industries of Qingdao is more than that of Qinhuangdao. Human resource is the guarantee of tourism development meanwhile tourism can increase employment much. The overall level of infrastructure of Qinhuangdao has a certain gap with Qingdao.

Analysis of tourism industry variables shows that the number of inbound tourists and highway mileage has certain relations for inbound tourists will surely consider traffic convenience besides other factors. The number of employees in accommodation catering industry is in agreement with the number of star hotels and catering companies. Hotels and catering industries cannot only increase employment but

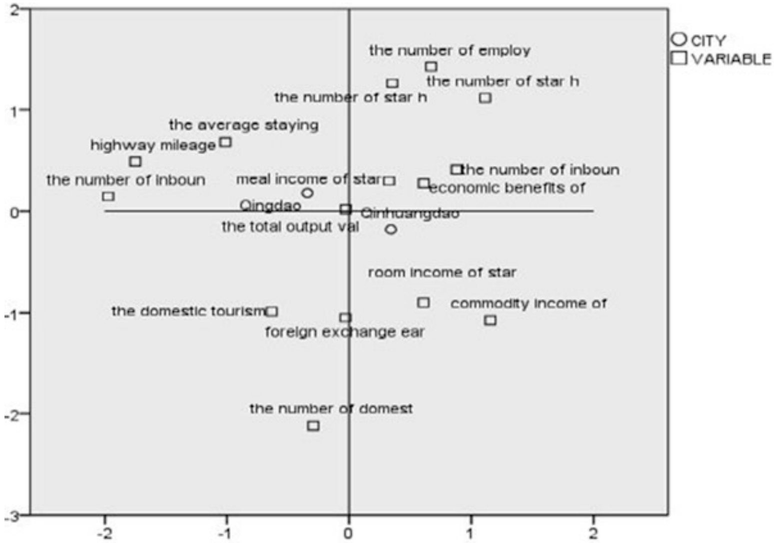


Fig. 2 Tourism industry inner relevance of Qingdao and Qinhuangdao based on optimal scaling technique

also promote the whole regional development. Foreign exchange earnings and the domestic tourism income depend on room income of star hotels and catering industries, which means tourism catering and tourism commodities are lack of diversity and attraction.

4 Discussion

In the Qingdao and Qinhuangdao influence analysis of different inner elements to foreign exchange earnings, we select 12 indexes which are highway mileage, the number of star hotels, the total output value of the tertiary industry, economic benefits of star hotels and catering industries, room income of star hotels and catering industries, meal income of star hotels, commodity income of star hotels and catering industries, the number of employees in star hotels and catering industries, the number of star hotels and catering companies, the number of inbound tourists, the number of inbound foreign tourists, the average staying days of inbound tourists and set them as *X1*, *X2*, *X3*, *X4*, *X5*, *X6*, *X7*, *X8*, *X9*, *X10*, *X11*, *X12* (Fig. 3) in order. In the Qingdao and Qinhuangdao influence analysis of different inner elements to the domestic tourism income, we select 10 indexes which are highway mileage, the number of star hotels, the number of domestic tourists, economic benefits of star hotels and catering industries, economic benefits of star hotels and catering industries, room income of star hotels and catering industries, meal income of star

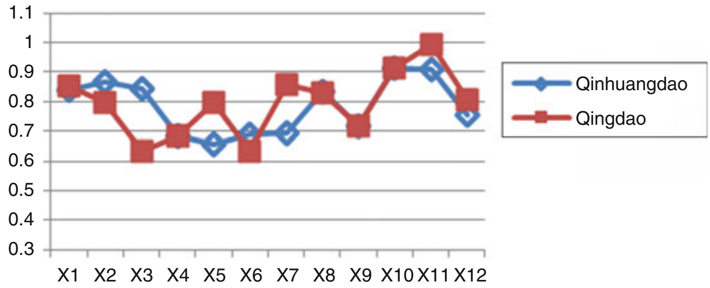


Fig. 3 Relational degree of foreign exchange earnings and influencing factors

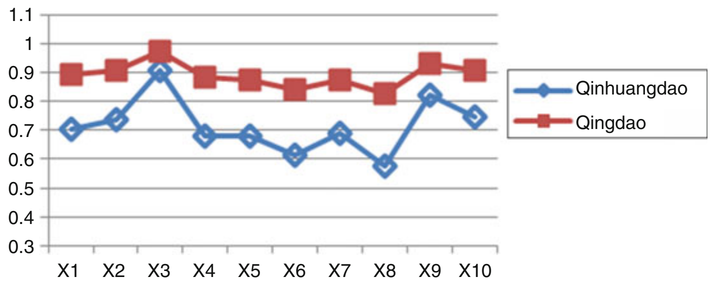


Fig. 4 Relational degree of domestic tourism income and influencing factors

hotels, commodity income of star hotels and catering industries, the number of star hotels and catering companies, the number of employees in star hotels and catering industries and set them as *X1*, *X2*, *X3*, *X4*, *X5*, *X6*, *X7*, *X8*, *X9*, *X10* (Fig. 4).

4.1 Influence of Different Elements to Foreign Exchange Earnings of International Tourism Based on Grey Relational Analysis

1. Foreign exchange earnings of international tourism and the inbound tourism are closely related. The number of inbound tourists and the number of inbound foreign tourists of Qinhuangdao and Qingdao rank in the top two and they have a high correlation degree. As a whole, the correlation degree of the number of inbound tourists and the average staying days with foreign exchange earnings in Qingdao are higher than that of Qinhuangdao, which means Qinhuangdao must be able to attract inbound tourists and attempt to promote the consumption of inbound tourists. However, the correlation degree of foreign exchange earnings and the average staying days of inbound tourists is 0.808, whose contribution is less important than that from the number of tourists. On the base of the date from 2006 to 2010, the average staying days of inbound tourists of Qinhuangdao

is higher than that of Qingdao. However the correction degree of the average staying days of inbound tourists and foreign exchange earnings of Qinhuangdao is 0.753, which reflects that more staying days do not produce effective economic benefits [10].

2. The influence of regional economic development and infrastructure condition to foreign exchange earnings is obvious. The total output value of the tertiary industry of Qingdao is four times of Qinhuangdao. In the factors that influence the foreign exchange earnings grey relational ordinal the total output value of the tertiary industry of Qinhuangdao is in the forth, but the total output value of the tertiary industry of Qingdao is in the twelfth, which reflects tourism is the biggest part in the tertiary industry of Qinhuangdao. The highway mileage correlation degree of Qinhuangdao and Qingdao are both rank in front, that is to say improving transportation condition can promote the development of international tourism. The grey relational degree of the number of star hotels and foreign exchange earnings of Qinhuangdao is 0.868 that ranks top three, but degree of Qingdao is 0.798 that ranks the seventh place. It reflects the more star hotels, the better tourism industry of a city.
3. The grey relational degree of star hotels and catering industries with foreign exchange earnings is relatively low. As to economic benefits of star hotels and catering industries in both Qingdao and Qinhuangdao, the influence from room income and meal income are low which means inbound tourists of these two cities tend to take part in diversified tourism more than pure sightseeing. The grey relational degree of commodity income of star hotels and catering industries with foreign exchange earnings of Qinhuangdao is 0.693 which ranks ninth in the grey relational ordinal, but that of Qingdao is 0.858 which ranks third in the grey relational ordinal. The richness and diversity of tourist commodities is one part to measure tourism development level. Tourist commodities can improve tourism economic benefits.

4.2 Influence of Different Elements to Domestic Tourism Income Based on Grey Relational Analysis

1. Undoubtedly, the grey relational degree of the number of domestic tourists and the domestic tourism income is on the top one. The degree of Qinhuangdao is 0.908 and that of Qingdao is 0.972. It means that the number of tourists can increase tourism income of Qinhuangdao domestic tourism more effectively. But for Qinhuangdao, the number of domestic tourists is much lower than that of Qingdao, that is to say Qinhuangdao has to improve the urban popularity and attraction.
2. Local economic development and infrastructure conditions have influence upon domestic tourism income and play a very important role in the city's overall tourism level. The grey relational degree of infrastructure and the domestic tourism income is in the top few in the grey relational ordinal. The grey relational

degree of highway mileage, the number of star hotels, the number of employees in star hotels and catering industries, the number of star hotels and catering companies with domestic tourism income are all lower than that of Qingdao. Because tourism of Qinhuangdao is at a lower level, tourism income can't be increased much more even if one element has greatly improved.

3. Catering industries have no significant influence on domestic tourism income. In terms of consume types of Catering industries, the grey relational degree of meal income and domestic tourism income is the highest and that of commodity income is lowest, which reflects both two cities stay in the pure sightseeing level in domestic tourism. The grey relational degree of Qinhuangdao is lower than that of Qingdao especially in commodity income. It reflects commodity of Qinhuangdao is lack of richness, diversity and attraction.

5 Conclusion

The aim of this study is to investigate the relationship between different elements in tourism industry and tourism development of Qinhuangdao. On the base of choosing benchmarking city and conducting grey relational analysis, we put forward the unbalanced development approaches in tourism industry of Qinhuangdao [11, 12].

5.1 Improve the Infrastructure Condition

Strength of infrastructure construction and improving service levels are vital for Qinhuangdao tourism [13]. The progress of improvement of the infrastructure must comply with the unbalanced thought, that is to say we should give priority to develop the most important parts of Qinhuangdao tourism including transportation, accommodation capacity level and information construction. These three aspects are the short slab of the infrastructure of Qinhuangdao tourism, which are also the foundation of tourism development [14].

5.2 Enrich the Tourism Product

Tourism product consists of two aspects, one is the tourist routes and tourist attractions, the other is traveling commodity and tourism food. Unbalanced development requires characteristics in these two areas. Tourist routes and tourist attractions must combine the unique history culture and folk culture of Qinhuangdao, as well as increase the value-added and technology content. While seeking characteristics for travel goods and travel food, we should also pay attention to the branding strategy [15].

5.3 Construct Characteristic Brand and Promote City Popularity

Under the fierce competition of Bohai Rim coastal tourism, Qinhuangdao must build an image of coastal historical leisure town and take advantage of unique historical stories, unique culture of the Great Wall and the unique leisure small city image to achieve inclusive growth. While in the process of exploitation and promotion of the city, Qinhuangdao must be unified in regional alliances to achieve overall development [16, 17].

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Optimization on Earned Value Method Combined with Critical Path

Qi-bin Zheng and Xing Bi

Abstract When calculating the schedule performance using the traditional earned value method, the earned value in the critical path and in the noncritical path is not differentiated. It cannot evaluate the progress of project objectively. In this paper, the schedule performance indicators are optimized through introducing the weight value, and schedule performance on the critical path is analyzed. The critical path issues in the evaluation of the progress of the project are solved, which will provide a basic point of reference for schedule measurement of project.

Keywords Critical path • Earned value method • Optimization • Weight value

1 Introduction

1.1 Introduction to the Earned Value Method

Earned Value analysis is a method of performance measurement which integrates cost, schedule and scope and can be used to forecast future performance and project completion dates [1]. The earned-value measurement concept was first introduced to the American defense contracting community when the government issued the Department of Defense and NASA Guide to Cost. Its techniques can still be applied to the smaller projects currently in use today. Indeed, as Microsoft Project allows you to drill down through and across a project, specific variances and general trends can be easily found. Its biggest feature is the combination of the two indicators of

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Table 1 Earned value management terms

Term	Description	Interpretation
PV	Planned value	What is the estimated value of the work planned to be done?
EV	Earned value	What is the estimated value of the work actually accomplished?
AC	Actual cost	What is the actual cost incurred?

Table 2 Earned value management formula and interpretation

Term	Formula	Interpretation
CV	EV – AC	Negative is over budget
		Positive is under budget
SV	EV – PV	Negative is behind schedule
		Positive is ahead of schedule
CPI	EV/AC	Greater than 1.0 indicates work is accomplished for less cost than what was planned or budgeted
		Less than 1.0 indicates the project is facing cost overrun
SPI	EV/PV	Greater than 1.0 indicates work is accomplished for less time than what was planned or budgeted
		Less than 1.0 indicates the project is facing time overrun

cost performance and schedule performance, supported by the payment system of incentives, which can improve capital efficiency and labor productivity in the project effectively [2]. Traditional earned value management is a kind of three-dimensional index system that contains the project scope, schedule and cost and is created by the introduction of the earned value variable [3].

Three quantities form the basis for cost and schedule performance measurement using Earned Value Management. They are Planned Value (PV), Earned Value (EV) and Actual Cost (AC) (Table 1). Additional terms are defined to record cost and schedule performance and program budget:

Schedule Variance (SV) – The difference between the work actually performed (EV) and the work scheduled (PV). The schedule variance is calculated in terms of the difference in dollar value between the amount of work that should have been completed in a given time period and the work actually completed.

Cost Variance (CV) – The difference between the planned cost of work performed (EV) and actual cost incurred for the work (AC). This is the actual dollar value by which a project is either overrunning or under running its estimated cost.

Cost Performance Index (CPI) – The ratio of cost of work performed (EV) to actual cost (AC). CPI of 1.0 implies that the actual cost matches to the estimated cost.

Schedule Performance Index (SPI) – The ratio of work accomplished (EV) versus work planned (PV), for a specific time period. SPI indicates the rate at which the project is progressing (Table 2) [4–6].

1.2 Defects of EVM

Traditional earned value method treats the project as a whole, focusing on the macro- analysis of project performance. It cannot distinguish the critical path from noncritical path activities, ignoring the restraining effect of the critical work on the entire project. For example, the earned value is less than the planned value in some projects behind schedule. On the contrary, the earned value is more than the planned value in some projects ahead of schedule. As long as the cumulative earned value of the entire project is enough, it can achieve a prefect project performance compared with the planned value. While the actual progress of the project implementation has not been reflected accurately [7–9].

2 Methodology

2.1 Optimization of Schedule Performance Indicators

The weight value is introduced in order to distinguish critical work from noncritical work in the calculation of schedule performance indicators.

2.1.1 Selection of Weight Value

In project management, Total Float (TF) is the amount of time that a task in a project network can be delayed without causing a delay to project completion date. An activity on critical path has zero free float [10]. Total Float can distinguish critical work from noncritical work and reflect various impacts on the entire project duration. Therefore, select

$$k_i = e^{(-TF_i)} \Big/ \sum_{i=1}^{n} e^{(-TF_i)} \tag{1}$$

as the weight value for activity i in the k-th day. k_i meets the following conditions:

$$0 \leq k_i \leq 1 \tag{2}$$

$$\sum_{i=1}^{n} k_i = 1 \tag{3}$$

2.1.2 Schedule Performance Indicators Modified

Planned Value of activity i in the k-th day with weight

$$PV_{k_i} = PV_i \times k_i \tag{4}$$

Planned Value of all activities in the k-th day with weight

$$PV_k = \sum_i PV_{k_i} \tag{5}$$

Earned Value of activity i in the k-th day with weight

$$EV_{k_i} = EV_i \times k_i \tag{6}$$

Earned Value of all activities in the k-th day with weight

$$EV_k = \sum_i EV_{k_i} \tag{7}$$

Schedule Variance in the k-th day with weight value

$$SV_k = EV_k - PV_k \tag{8}$$

Schedule Performance Index in the k-th day with weight [11]

$$SPI_k = EV_k / PV_k \tag{9}$$

2.1.3 Steps of Earned Value Analysis with Weight

Step 1: TF_i of work i is calculated according to the network diagram. And identify key work on critical path.
Step 2: The weight value for activity is calculated.
Step 3: Calculate Planned Value of activity i in the k-th day with weight PV_{k_i}. Then Planned Value of all activities in the k-th day with weight PV_k is also obtained.
Step 4: Calculate Earned Value of activity i in the k-th day with weight EV_{k_i}. Then Earned Value of all activities in the k-th day with weight EV_k is also obtained.
Step 5: Calculate Schedule Variance in the k-th day with weight value SV_k and Schedule Performance Index in the k-th day with weight SPI_k according the figures above.
Step 6: Analysis and gives the results of the evaluation of the project.

2.1.4 Earned Value Analysis Based on CPM

Schedule performance indicators modified show the difference between the critical path and noncritical path. Schedule performance on critical path can be measured. The strategy used is to assume two parameters: PV_{cp} (Planned Value on critical path) and EV_{cp} (Earned Value on critical path).

Schedule Variance on critical path

$$SV_{cp} = EV_{cp} - PV_{cp} \tag{10}$$

Schedule Performance Index on critical path

$$SPI_{cp} = EV_{cp}/PV_{cp} \tag{11}$$

SV and SPI on the entire project can be compared with SV_{cp} and SPI_{cp} on the critical path, which will determine schedule status on the critical path. These conditions can be divided into four types [12, 13]:

1. $SV < 0, SV_{cp} < 0$
   The work on the entire project and the critical path are behind schedule. It is high time to take certain measures to accelerate the implementation of activities on critical path and make sure whether activities on noncritical path can been completed in a given time period. If the deviation is not enough to cause a delay to project completion date, it is not necessary to take measures. Otherwise, there is a need to speed up the construction on noncritical paths and get schedule.
2. $SV < 0, SV_{cp} > 0$
   On the whole, the progress of the project will be delayed. But the work on critical path is ahead of schedule. Add more resources on noncritical paths and expedite the construction. It is necessary to avoid noncritical path convert into critical path.
3. $SV > 0, SV_{cp} > 0$
   The work on the entire project and the critical path actually performed are more than the work scheduled. The project can be fulfilled ahead of schedule. But it cannot be achieved at the expense of cost. It will affect the completion of future work, if the cost is too high.
4. $SV > 0, SV_{cp} > 0$
   On the surface, the project is ahead of scheduled, while it is behind schedule in fact. Because the work on critical path is not completed in a given time period. The efficiency of the work packages on critical path should be improved and resources distribution should be optimized appropriately.

3 Application and Results

A project includes seven tasks: A, B, C, D, E, F, G. The network planning is showed in Fig. 1. The completion duration of the project planned is 22 weeks and project performance is monitored every week. EV, PV and SV of all work are measured in dollars. It is obvious that A-B-C-F-G is on the critical path. On the 7th week, all activities are assessed and the progress and costs related are shown in Table 1.

Performance Index figures in Table 3 can be calculated from Table 4.

We now have a clearer picture of the actual status of the work. In the following 7 weeks, task A, B, D have been fully completed. 25 % percentage of C and 60 % percentage of E have been accomplished. Task F and G have not started.

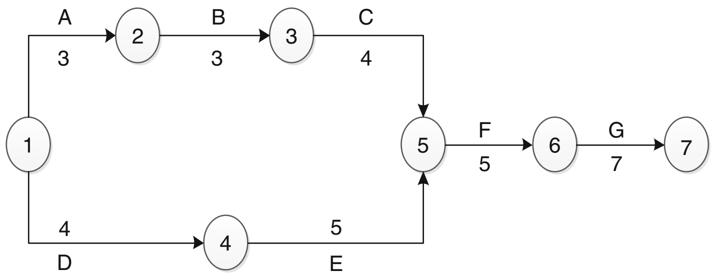

Fig. 1 The network planning of a project

Table 3 Summary of work schedule and performed

Task	PV	EV	Planed work/%	Actual work/%
A	90	110	100	100
B	100	100	100	100
C	70	0	25	0
D	100	120	100	100
E	80	140	60	100
F	120	0	0	0
G	150	0	0	0

Table 4 EV schedule analysis

Task	Duration	TF	Weight/%	PV_i	EVi	PV_{ki}	EV_{ki}
A	3	0	26.77	90	90	24.10	24.10
B	3	0	26.77	100	100	26.77	26.77
C	4	0	26.77	17.50	0	4.68	0
D	4	1	9.85	100	100	9.85	9.85
E	5	1	9.85	48	80	4.73	7.88

The results gained by earned value method are as follows:

$$PV = 355.5 \quad EV = 370$$

$$SV = EV - PV = 14.5$$

The whole project is ahead of schedule because $SV > 0$.

The figures gained by earned value method with weight value are as follows:

$$PV_k = 70.13 \quad EV_k = 68.6$$

$$SV_k = EV_k - PV_k = -15.3$$

The whole project is behind schedule because $SV_k < 0$.

Thus completely opposite results are drawn by different ways. In order to get the reasons, we continue do schedule performance analysis based on critical path. Some schedule performance indicators on critical path are calculated.

$$PV_{sp} = 207.5 \quad EV_{sp} = 190$$

$$SV_{sp} = EV_{sp} - PV_{sp} = -17.5$$

The work on critical path is behind schedule because $SV_{sp} < 0$.

It can be concluded that the project is ahead of scheduled on the surface, while it is behind schedule in fact. Because work E on the noncritical path actually performed is more than the work scheduled, while work C is on the contrary. The reason that E can be in advance is a significant increase in cost. Work D is completed timely which is also a reason for the added cost. So it is time to take certain measures to accelerate the implementation of activities on critical path. For example, we can increase the equipment and personnel inputs rapidly, take the advanced technical measures and dispatch resources appropriately, and so on. Meantime, the cost inputs on noncritical work packages should be controlled in case of increase in cost deviation [14–16].

4 Discussion

Schedule performance indicators including SV and SPI are measured by cost, not by time. This method is not intuitive, and it is also difficult to operate. Thus, it is necessary to do further research to optimize Schedule performance indicators.

5 Conclusion

Therefore, Earned Value Method is a better method of program management. It is an "early warning" program management tool that enables managers to identify and control problems before they become insurmountable. But we cannot gain accurate information about the project based on the overall analysis and evaluation of project by traditional earned value method. We can optimize schedule performance indicators by introducing weight value in order to distinguish critical work from noncritical work. Then we can do schedule performance analysis based on critical path. It can show project progress objectively and accurately and allow us take timely measures to correct deviations. It also provides a basic point of reference for schedule measurement of project and allows projects to be managed on time and on budget.

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Analysis the Western Colleges and Universities of Science and Technology Innovation Team Building Under the Shared Leadership Theory Horizon

Xiao-qin Zhu and Zhao-hui Du

Abstract With the advent of knowledge economy, innovation is becoming more and more important, also more and more complicated. Gather the collective wisdom of science and technology innovation team to support and lead economic society, which plays a more and more important role for sustainable development. Then, how to build the science and technology innovation team and make it playing itself maximum energy, which becomes a currently problem for solved. In this paper, introducing the latest theory of leadership – the shared leadership model, through sum up the definition and contents of the shared leadership, explore the new ways of scientific and technological innovation team building.

Keywords Innovation • Science and technology innovation team • Shared leadership • Western colleges and universities

1 Introduction

In recent years, the western colleges and universities has a great progress in the national and provincial of projects and all kinds of science and technology award, It plays an irreplaceable role for the social development and the progress of science and technology in the western region. But due to various reasons such as history, the western colleges and universities is behind many of the more developed eastern areas in the scientific research strength, In order to close the gap, it is only through the strengthening innovation efforts to catch up. The science and

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technology innovation team as the main scientific research force in the colleges and universities [1], It is affected by the resource constraints and the improper allocation of resources, It still appear many problems in construction: The absence of strong science and technology innovation team, the knowledge resources cannot be Shared effectively, the team continuous innovation ability is weak, the brain drain phenomenon is relatively serious and so on many problems [2]. In a certain extent, they have restricted the development of science and technology innovation in the western colleges and universities.

Operations team have a biggest drawback, it is difficult to arouse the enthusiasm of all people, How to maximize the synergy effect, which has become the realistic problem for leading contemporary leadership theory. The rise of shared leadership theory has become a new effective way in the 1990s. The empirical research shows that the shared leadership has more stronger innovation ability, Because, compared with the traditional information transmission and instructions from top to bottom, the way of autonomous decision-making and autonomous management can reduce the working procedures, reduce the information distortion degree, increase the flexibility of the field strain, and at the same time it can also inspired the knowledge staff's work enthusiasm for making the team work more efficient. Hui-Ying Mei Ph.D. (2011) founds that the shared leadership style has significant positive influence on employee innovative behavior by empirical test [3].

2 The Connotation of Sharing Leadership

In the early 1980s, many people have realized that the high performance group often has no formal leadership structure (Manz and Sims 1984). The leadership style is often Shared [4]. With the evolution of the environment, the leadership gradually became a relatively complex process, The shared leadership will go with the idea of a dynamic and mutual to understand the leadership at this point, Pearce and Conger (2003) thinks that the shared leadership is a dynamic and interaction influence process between individuals in the team, it usually involves with hierarchy between, sometimes involving other hierarchy, such as the up or down of the hierarchy [5]. Wood (2005) consider the shared leadership is a kind of mutual influence conditions or characteristics, In this state, team members share in a leadership role, together to participate in the decision-making process and finish the task, and it has provided guidance to others in order to achieve group goals at the appropriate time [6]. Though scholars have a different view on the definition of Shared leadership, But they all emphasize leadership is not just a personal thing, the leadership is a dynamic change by all the team members, each team member has a dynamic change between leader and subordinate two roles with different tasks. So, the shared leadership can be defined as a state: according to the characteristics of task, team members share the leadership roles, and together participate in the decision making process, and each other mutual influence and mutual cooperation for achieving team and organizational goals [7]. The function of leadership can be shared by two or more

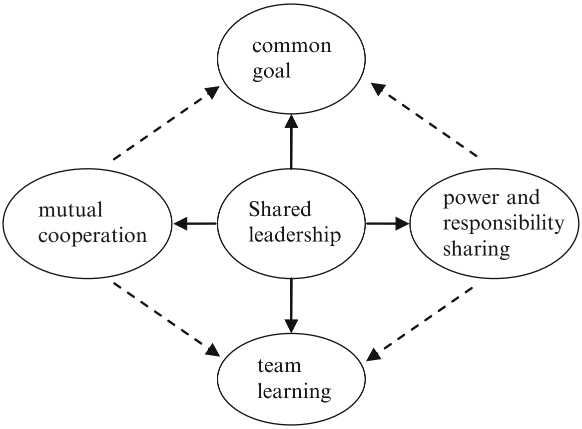

Fig. 1 Structure of shared leadership

team members and the leader should have the knowledge, abilities, skills that the task requires. Second, the leadership role has changed with the tasks and situation [8]. Third the influence of shared leadership is multi-directional, not only including the vertical impact of formal leadership, but also the interaction between team members [9].

Mayo etc. (2002) has taken the share leadership decompose into the decentralization of team and the degree of shared leadership, the former refers to the proportion degree of the team members to assume leadership roles than team centralization [10]; The latter refers to the team members feel the amount or degree of the leadership influence. Carson etc. (2007) take "common goals, social support and suggestions of employees" as three dimensions for measuring the degree of the shared leadership [11], through the empirical research for enterprises in Guangzhou, Liu Bo Yi (2009) puts forward the content of Shared leadership has four factors such as "performance expectations, team learning, cooperation, sharing of responsibilities" [12]. Lin Jun etc. (2011) put forward four dimensions from the theory, respectively is the "power and responsibility sharing, mutual influence, voice and common goal" [13]. Among them, the power and responsibility sharing refers to a platform for team playing leadership skills, members have access to obtain leadership power and assume leadership responsibility; Interaction refers to the team members play the influence of interaction, dynamic and the role between individuals in leadership roles; voice refers to the members have the extent of voice; Common goal refers to team members common identity the team basic goals to ensure that the work emphasis on collective goals.

Combined with the above research, the contents of the Shared leadership can be integrated into the following four dimensions: common goals, mutual cooperation, power and responsibility sharing, team learning, the structure shown in Fig. 1. Because, the common goal can indicate the existence reason and meaning of the team, and providing reference for decision-making in operation of the team; mutual cooperation can achieve the modular and the perfect combination of the collective wisdom; Power and responsibility sharing cannot only arouse the enthusiasm of all team member, but also prevent mutual shuffle; Team learning can guarantee team progress and constant innovation ability. And these four dimensions are interrelated each other, mutual collaborate, powers and responsibilities of sharing not only promote the realization of the common goal, also contribute to the team learning, team learning through the improvement of collective skills and knowledge, indirectly contribute to the realization of the common goal.

3 Based on the Shared Leadership, the Scientific and Technological Innovation Team Structure in the Western Colleges and Universities

Team members the ability of learn, the stronger, more suitable for the use of shared leadership. Porter and Wilson (1995) in their study proposed that the strong learning ability of the team members will help team members understand the connotation of shared leadership formation process and, how the implementation of leadership behavior [14]. In Characteristic aspects of the task, the work is more complex, the higher the degree of task related the higher tasks innovative, more suited to the use of shared leadership. Pearce and Manz (2005) in their study indicated that the reason why the shared leadership with traditional hierarchical leadership in motivating employees incomparable advantages in innovation [15]. Shared leadership, encourage team members through self-leadership and influence other team members to identify problems, analyze and solve problems, making it easier to identify the opportunities and challenges of shared responsibility, then you are more likely to generate knowledge and innovation [16]. The task of correlation degree is higher, which need more collaboration among team members for accomplishing the team goals, Latane etc. [17] also confirmed this idea in the study. Scientific and technological innovation team members are highly educated personnel, the fundamental task is the innovation, in the knowledge economy innovative facing increasing pressure and difficulty. So it is very suitable for the establishment of a shared leadership model.

3.1 The Composition of the Elaborate Design Team

Team composition contains personnel quantity, age structure, knowledge background, research direction, head of choice, etc. To achieve shared leadership model, the science and technology innovation team is at the beginning of the form, it must be to realize optimized configuration in terms of team composition. The number of the first, team members should not be less than 5 people, too little is bad knowledge collision sparks, but also should not be more than 10 people, too many not easy to control; Second, Second, the three stages of age structure should be normally distributed, less on both ends, more in the middle, so that middle-aged people are conducive to the stability of the team and talent cultivation; Knowledge should be given priority to with highly educated talents, so that is conducive to innovation; Research direction and field should be diversified for facilitate discipline crossing and penetration; The team leader should be teachers with double charm of personality and academic, because under the influence of the ranking, some colleges and universities of science and technology innovation team management have obvious tendency of town government, such as administrative power generalization, academic power weakening phenomenon, So, as a team leader, he should avoid by administrative leadership.

3.2 Establish Combines Research Direction, Expected Results, and Personal Development for the Integration of Team Goals

Many scientific and technological innovation team often access to resources and application project as a purpose, if the task should be completed, the scientific and technological innovation team should be disbanded, then a temporary form should be establish for new resources, the team life usually in 3 years or so, difficult to maintain the lasting vitality. This way is against national file spirit, and delay the timing of the school development. In short, the scientific and technological innovation team lack of clear team goals, or objectives, or focus on the future. In order to achieve the shared leadership models, it must be to set clear, long-term and a common team goal, then, it should include three aspects of content at least: the first is the team's research direction, a clear research direction can guide and attract the team members for fight, and maintain the stability and development of the team; the second is the future of the team expected outcomes, more members can move and inspire with the clear expected outcomes, and provides the reference and basis for the team to plan and organize work; The third is the future personal development plan of the team members, this is a matter of each person in the development of team goals, it can deeply make the team and individual together, easy to form the thoughts of team and personal interest and personal loss, this is more violent than material incentives.

3.3 Form Team Culture of Innovative, Caring and Inclusive

Any an innovation is a difficult and hardship of a long journey, if the team has no desire for success, no care about each other's team spirit, the process of innovation setback easy to make members losing morale and confidence, the team is also easy to lack the strong spirit of dedication and responsibility. Therefore, building a shared leadership model of science and technology innovation team must build their own team's culture, the culture needs to contain elements such as innovation, care, tolerance and so on. Innovation is an eternal subject for research, Innovation can be as a guide to inspire members constantly learning and exploring; Team members may come from different positions, different departments, each other understanding degree is not enough and lacking of trust, and knowledge owners in order to protect their own uniqueness, they naturally inclined to have knowledge of "monopoly", which is not conducive to team collaboration. Therefore, it must create conditions to strengthen the personal communication between members in the process of the team. Public-private partnerships to entwine together is a characteristic of Chinese interpersonal relationship, interaction can make the team members to private feelings deepen, produce intimate relationship, it can make the team members to perceive each other care and status, to enhance an individual's sense of identity and belonging and provide information exchange conditions; Tolerance is a kind attitude of team, innovation itself has the risk, if lacking of tolerance of failure, then team members easy to bind their free association and innovation action.

4 West University of Science and Technology Innovation Team Safeguard Measures Based on Shared Leadership

4.1 Actively Implement the Team and the Enterprise Communication Platform

It was found that many colleges and universities scientific research have disconnect with the requirements of social and enterprise in the survey, this lead to enterprise nowhere to solve many problems, the school staff complain that have no chance to make some projects, the main cause of this situation is a unsound bridge between college and enterprise. Although the theoretical circle has repeatedly stressed to construct linkage, but due to improper way, that less implement the way. In order to build science and technology innovation team, It must have the correct research direction at first, many researchers had never left the school and poorly understood with the enterprise actual operation condition, So, it is difficult to discover valuable subject. The western colleges and universities should begin from the basic to start at first, it must provide a platform that the scientific research personnel can exchange with enterprise, let them really understand to what enterprise need, such as become the enterprise alliance partners, personnel exchange with other units for exercise, or regularly invited enterprise senior management personnel communicate with teachers for discuss, or set up external liaison department, it can responsible for the scientific research personnel to contact foreign.

4.2 Optimization of Evaluation System and Evaluation Method

The science and technology innovation team of shared leadership model should be a strong vitality and sustained research team in university, when evaluating its performance, which cannot be measured by single index system. From the content, the performance should evaluate in two aspects from the team overall performance and team members performance. As the whole team performance is evaluated, according to team goal and team capabilities, it must comprehensive considerate from the academic value of scientific research achievements, economic value, the cultivation of the talents, team management; When evaluating team performance, not only evaluate the scientific research results of the team members, but also assessment of the potential contribution to the team, scientific research ability, scientific research and moral standards, this will lead to a comprehensive accurately evaluation. Speaking from the stage, it must consider team's stage of development, this evaluation can be divided into the initial evaluation, interim evaluation and the end of the evaluation, the evaluation content of each stage depends on the research progress of scientific research project. As for the evaluation method, the traditional evaluation method can't very good evaluate to the team of science and technology in colleges and universities, the whole and the team members' performance can be accurately evaluate only by adopting the combination of qualitative and quantitative methods, such as analytic hierarchy process + comprehensive appraisal method.

4.3 Increase the Intensity of Training and Rich Incentives

At present, in order to motivate the school staff vigorously devoted himself to scientific research, the western colleges and universities gives heavier economic incentives in major scientific research achievements, it has a great temptation for general scientific research team, but in terms of the scientific and technological innovation team members of shared leadership model, as for improving the research level and management ability, its incentive effect is better than the domestic education, short-term training and study abroad. In information and knowledge-based era, knowledge obsolete and update frequency become more and more fast, the most important premise of innovation is timely access to relevant areas of knowledge and information. Therefore, schools can from training content, training time, training form, number of training leaning to scientific and technological innovation team members. In terms of incentives, in addition to economic means, it can help increase incentives means for implementation team or individual needs.

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An Innovative Methodology of Systematic Strategy: Key Success Paths Approach

M.F. Wu, F.T. Cheng, and P.L. Chang

Abstract Highly developed technology and a highly competitive global market highlight the important role of operation strategy in sustaining competitive advantage for survival. This paper explores and constructs the methodology of key success paths (KSPs) approach to provide the strong explanatory power relationships among all of key success factors (KSFs) with multiple performance levels and their specific successful outcomes. Success or failure paths explored through KSPs approach are important guidelines for operation strategy to achieve specific well-performed outcomes. The findings of the paper are: (1) more than one path may achieve to success or failure outcomes. (2) Key success/failure paths will lead the ways to promote the efficiencies. (3) The company may select proper key success path to combine multiple performance levels of KSFs which bases on its competitive advantages. Threefold contributions in this paper are: (1) constructs the KSP Approach to explore the relationships among KSFs and specific outcomes of strategic management; (2) identifies KSPs that help ensure the success of strategy management; (3) provide transformation mechanism for KFPs so as to transform into KSPs.

Keywords Key success factors • Key success paths approach • Key failure paths • Key success paths • Strategy management

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1 Introduction

Key success factors (KSFs) are information ingredients with unique characteristics and are heuristic tools for thinking, skills, and resources allocation for successful outcomes [1].

Statistical method is one of the methods that are able to explore, to present and to predict the causal relationships between causal condition (e.g. KSFs or independent variable) and outcome (e.g. dependent variable). Such as applying in NPD research to explore the relationship among KSFs and NPD performances with mean value, significance of differences in means measures [2–8].

The significant positive relationship between KSFs and outcomes indicates that the benchmark has successful outcomes because all of KSFs are in highest performance levels. Yet, be a benchmark is not so easy because of huge resources needs to invest. Very few studies present specific combinations for the successful or failed causal relationships adequately.

Qualitative comparative analysis (QCA), fuzzy set qualitative analysis (f/s QCA) and rough set theory (RST) [9–11]. The previous two methods are used to explore the causal relationship in social and political issues; the last method is applied in R&D study [11].

The advantages of those approaches include better-suited than regression for exploring causal configurations, allow the identification of multiple paths to an outcome, useful in examining the general tendency of a particular factor to influence an outcome and explore a different kind of relationship [12]. However, the two main disadvantages of these approaches are: lack of some causal conditions/KSFs to explain or predict the outcomes of causal relationships in the paths, and the inability to indicate the performance level that should be performed in causal conditions/KSFs.

The main objective of this paper is proposed new approach: “Key Success Paths Approach” to explore the key success paths (KSPs) and key failure paths (KFPs). “Path” has been studied in many academic disciplines [13, 14]. In this research, “path” presents the causal relationship which is combined of all KSFs with multiple performance levels to achieve specific successful or failed outcomes. The key success path (KSP) combines with all of the KSFs to achieve the specific success outcome; the key failure path (KFP) combines with all of the KSFs to achieve specific failure outcome.

The second main objective is to examine the arguments for the KSP approach: (1) no individual KSFs is sufficient for KSPs; (2) more than one KSP lead to specific successful outcomes; (3) more than one KFP experiences specific failed outcome; (4) Several identifiable KSPs and KFPs which are “remainders” which are never taken even though they may be possible used for implementation; (5) several specific alternative combinations occur in successful outcomes frequently; (6) several specific alternative combinations occur in failed outcomes frequently; (7) Few KSPs lead to exceptional success; (8) Few KFPs lead to exceptional failure.

The third objective is to provide two-stage adjustment process to transform KFPs into KSPs during short-run and long-run periods. There need to upgrade performance level of KSFs during adjustment processes. The criteria of the adjustment process from KFPs to short-run, or from short-run to long-run period should be limited to two or three KSF items. Through reasonable efforts and resource invests that will encourage senior managers and faculties to sustain or upgrade their core competencies and competitive advantages in the company and industry.

2 Methodology

This paper constructs “Key Success Paths (KSPs) Approach” [15] to overcome the weaknesses of previous research methods, to explore key success/failure paths to provide guideline for operation strategy.

The advantages of key success paths (KSPs) approach are: (1) combine all of the key success factors (KSFs) to explore the key success paths, avoid the absence of anyone of KSF, (2) provide multiple performance levels for all of the KSFs in the KSPs or KFPs.

The algorithm process of KSPs approach is shown in Fig. 1 and process are described as following [15].

Step I. Select and Define Key Success Factors (KSFs). Proper KSFs are the causal conditions that illustrate the outcomes of event more explanatory power and avoids the lengthy process time in QCA [10].

Step II. Data Collection. Embedded all of the KSFs and specific outcome in questionnaire design which with ten Likert scales, interviews the senior manager and faculties to collect data. The collected data are demonstrated in Table 1.

Step III. Set up Fuzzy Range Scope. The algorithm applies fuzzy theory with common triangular membership function to divide KSFs into three different performance levels. The triangular membership function show as Eq. (1) and Fig. 2 [9]:

$$\mu_{\tilde{A}}(x) = \begin{cases} 1 - \left[\frac{b-x}{\alpha}\right], b - \alpha \leq x \leq b \\ 1 - \left[\frac{x-b}{\beta}\right], b \leq x \leq b + \beta \\ 0, \textit{otherwise} \end{cases} \tag{1}$$

Each performance level of KSFs should set up its own membership fuzzy range to calculate the fuzzy set membership score with Eq. (1). This paper dividends the variance between the highest and lowest value of each KSF into three performance levels, selects KSFs from first four rows in the Table 1 for demonstrating the algorithm procedures and fuzzy range scope are listed in the Table 2.

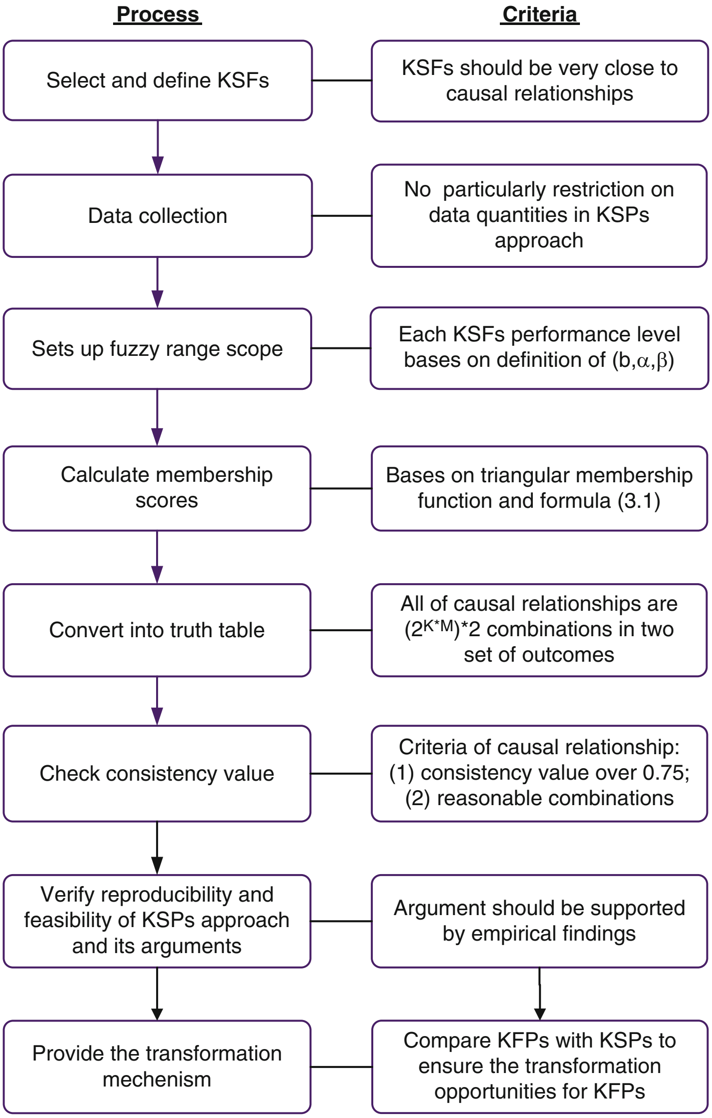

Fig. 1 Key success paths approach process

Step IV. Calculate Membership Scores. This step uses a rudimentary three-value fuzzy set with three breakpoints [16] to calculate the membership score. The membership scores are presented in Table 3.

Step V. Convert into Truth Table.

This step can be conceptualized as a bridge with three pillars. (1) The direct correspondence that exists between the rows of a crisp truth table and the corners

Table 1 Demonstrated of collected data

	Cases		
KSFs	A case	B case	C case
X_1	3	8	2
X_2	7	8	9
X_3	7	2	8
X_4	7	2	8
⋮	⋮	⋮	⋮
X_n	5	9	4
Y	4	5	8

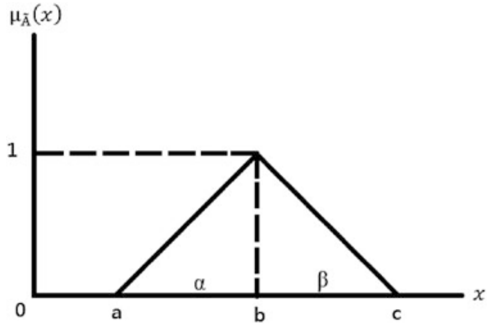

Fig. 2 Triangular membership function

Table 2 Fuzzy range scope for KSFs

	Low level	Medium level	High level
X_1	Under 4.00	4.00–6.00	Over 6.00
X_2	Under 7.67	7.67–8.33	Over 8.33
X_3	Under 4.00	4.00–6.00	Over 6.00
X_4	Under 4.00	4.00–6.00	Over 6.00
Y	Under 5.33	5.33–6.66	Over 6.66

Table 3 Fuzzy membership score for the KSFs

KSFs	X_1			X_2			X_3			X_4			Y		
Cases	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L
A	0.09	0.11	0.80	0.60	0.30	0.10	0.60	0.30	0.10	0.60	0.30	0.10	0.10	0.15	0.75
B	0.85	0.05	0.10	0.70	0.25	0.05	0.30	0.10	0.60	0.30	0.10	0.60	0.20	0.20	0.60
C	0.20	0.20	0.60	0.75	0.10	0.15	0.70	0.25	0.05	0.70	0.25	0.05	0.80	0.15	0.05

of the vector space defined by fuzzy set causal conditions [9]. (2) Assess the distribution at cases across different logically possible combinations of KSFs. (3) assess the consistency at each causal combination with the argument that it is a fuzzy subset of the specific outcome [16].

This paper selects the first four binary, and divides each binary into three performance level for illustration, the truth table will contain 2^{K*M} (i.e., $2^{4*3} = 4{,}096$) rows. K represents the number of KSFs; M represents the number of performance

Table 4 Partial truth table associated with high performance

Causal relationship	1 h	1 m	1 l	2 h	2 m	2 l	3 h	3 m	3 l	4 h	4 m	4 l	Cases	Out-H	Consistency
1	1	0	0	1	0	0	1	0	0	1	0	0	0	1	0.830508
2	1	0	0	0	1	0	1	0	0	1	0	0	0	1	0.886364
3	1	0	0	0	1	0	1	0	0	0	1	0	0	1	1
4	0	0	1	0	1	0	1	0	0	0	1	0	0	1	0.6
5	0	0	1	0	0	1	1	0	0	1	0	0	0	1	1
6	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0.833333
7	0	0	0	0	0	0	0	1	0	1	1	0	0	1	0.818182

levels. If the outcome value divides into two-value set, there are two subsets of possible raw data matrix.

Truth table is necessary to reconstruct a raw data matrix by using Boolean algebra as a technique of qualitative comparison to represent data. Each logical combination of values on the KSFs is represented as one row of the truth table [9], and assigned an outcome value (either 1 or 0) based on the scores of the cases which share the same combination of KSFs. The partial truth table associated with high performance outcome presents in Table 4.

Step VI. Calculate Consistency Value.

Consistency measures the degree to which the entire KSFs combinations of causal relationships are subsets of the specific outcomes [16]. The calculation of consistency and coverage value are shown in formula (2) and (3):

$$\text{Consistency}\ \ (X_i \leqq Y_i) = \frac{\sum \min\left(X_i.Y_i\right)}{\sum \min X_i} \tag{2}$$

$$\text{Coverage}\ \ (X_i \leqq Y_i) = \frac{\sum \min\left(X_i.Y_i\right)}{\sum Y_i} \tag{3}$$

X_i represents: the multiple (i) of KSFs (X), and Y_i represents: the multiple (i) of outcome (Y).

Two threshold criteria for identifying KSPs or KFPs are: (1) consistency value should over 0.75; (2) combination of KSFs in causal relationship should be reasonable. If consistency value of causal relationship is under 0.75, then the causal relationship must be trashed in the first step [15, 16].

The qualified causal relationships associates with high value set of outcome are identified as KSPs; and the qualified causal relationships associate with low value set of outcome are categorized as KFPs.

The second threshold criterion is to thresh the unreasonable causal relationships in the truth table. The 6th row in Table 4 should be threshed because only X_4 in high performance level and missing rest of the others; the 7th row should be threshed

Table 5 Key success paths (KSPs)

KSPs	X_1	X_2	X_3	X_4	Cases	Out-H	Consistency
1	M	H	M	M	0	1	0.972222
2	M	H	M	H	0	1	0.972222
3	M	H	H	M	0	1	0.972222
4	M	H	H	H	0	1	0.972222
5	H	M	L	L	0	1	0.871795
6	H	M	L	H	0	1	0.871795
7	H	M	H	L	0	1	0.871795
8	H	H	H	H	0	1	0.830508
9	H	H	L	H	0	1	0.772727
10	H	H	H	L	0	1	0.772727

Table 6 Key failure paths (KFPs)

KFPs	X_1	X_2	X_3	X_4	Cases	Out-F	Consistency
1	L	M	H	M	0	1	0.9
2	L	M	M	H	0	1	0.9
3	L	M	M	M	0	1	0.9
4	L	M	H	H	0	1	0.9
5	H	M	H	M	0	1	0.827586
6	H	M	M	H	0	1	0.827586
7	H	M	M	M	0	1	0.827586

because X_1 and X_2 are missing and X_4 is in medium and high performance level in the same row.

Step VII. KSPs and KFPs.

The qualified and reasonable causal relationships should transform from truth table into KSPs/KFPs. These two causal relationships with specific KSFs combinations and their associated outcomes are names "KSPs or KFPs" in this paper.

There are 10 KSPs been explored in Table 5. The 1st KSP combines with three KSFs of medium performance level and one KSF of high performance level of KSFs, and causes to high performance level of outcome Y with strong explanatory power because of its consistency value is 0.972.

There are 7 KFPs been explored in Table 6. The 1st KFP combines with two KSFs of medium performance level, one KSF of low performance level and last one is high performance level, with low performance level of outcome Y and strong explanatory power because consistency value is 0.828.

Step VIII. Provide Transformation Mechanism.

For transforming KFPs into KSPs, the paper proposes two-stage adjustment process for improving current status. The "Two-stage" represents short-run and long-run period; and the "adjustment" represents upgrading the performance level of KSFs from low to medium or high performance level; and the "process" represents the step-by-step for adjustments. Therefore, Two-stage adjustment process represents step-by-step to adjust performance level in specific KSFs in KFPs to transform into KSPs in short-run and long-run period.

The two-stage framework provides dynamic concepts and threshold criteria to explore the chances with comparing the KSFs combination with KFPs and KSPs. Transform failure into success that will reduce unnecessary resource wastage, and avoid uncertain risks, and also highlight the opportunities for senior manager and faculties to pursue the success outcomes. The two-stage adjustment process is shown in Fig. 3.

The seven sequential steps of two-stage adjustment process are presented as follows.

Step I. The company should have an operation committee and members, including senior managers and faculties of qualified work teams, to discuss and agree on the operation goals, process, and criteria.
Step II. Decide on which KFPs to terminate or to adjust.
Step III. Extract specific KSPs with consistency value under 0.80 as short-run KSPs to make sure transformation will be easily accomplished for the company.
Step IV. Compare KFPs and specific short-run KSPs one-by-one with all of KSFs combinations. The transformation criterion is less than three items of KSFs.
Step V. The operation committee should decide whether or not the short-run KSPs should transform into long-run KSPs continuously. The consistency values of long-run KSPs are over 0.80.
Step VI. Repeat comparison with short-run and long-run KSPs respectively to make sure the transformation opportunities as Step VI.
Step VII. Some short-run KSPs have only one chance and the others will have more opportunities. The transformation criteria should be limited to two KSFs upgrading for easily accomplishing.

3 Results

Exams all of 10 KSPs and 7 KFPs, the research proposes arguments as following:

1. *No individual KSF is either sufficient or necessary for the KSP or KFP.* This argument is supported by the combinations of KSFs/KFPs as X_1, X_2, X_3 and X_4 with multiple performance level in Table 5 and also in Table 6.
2. *More than one path leads business to specific operation success or failure outcomes.* This argument had been supported by 10 KSPs in Tables 6 and 7 KFPs in Table 6 individually.
3. *Several identifiable KSPs or KFPs are rarely or never taken even though they may be possible to implement.* (These are "remainders" in the fuzzy set theory). All of these remainders have strong explanatory power but could not been adopted yet. This argument is supported by Table 5 with KSPs and Table 6 with KFPs.

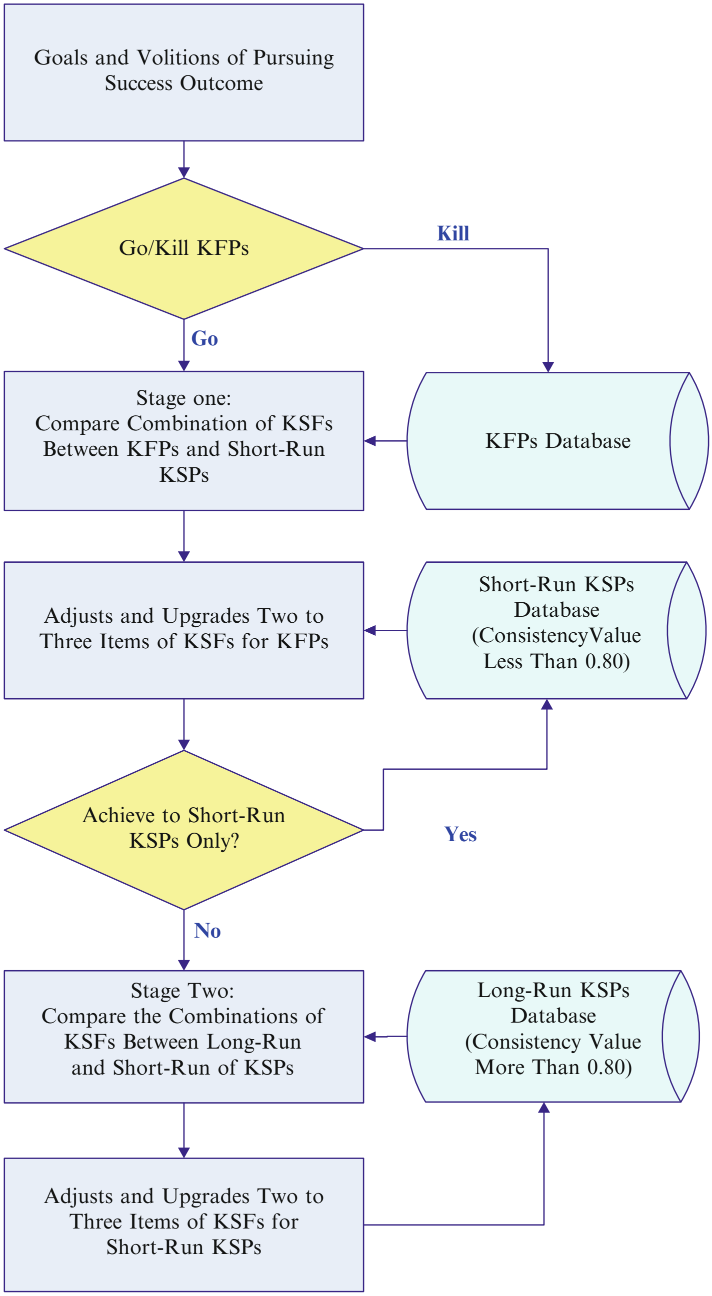

Fig. 3 Two-stage adjustment process flow

Table 7 Exceptional key success paths

KSPs	X_1	X_2	X_3	X_4	Cases	Out-H	Consistency
1	M	H	M	M	0	1	0.972222
2	M	H	M	H	0	1	0.972222
3	M	H	H	M	0	1	0.972222
4	M	H	H	H	0	1	0.972222

Table 8 Exceptional key failure paths

KFPs	X_1	X_2	X_3	X_4	Cases	Out-F	Consistency
1	L	M	H	M	0	1	0.9
2	L	M	M	H	0	1	0.9
3	L	M	M	M	0	1	0.9
4	L	M	H	H	0	1	0.9

4. Some specific alternative combinations of KSFs occurred frequently in specific success or failure outcomes.
   (1) Examine all of 10 KSPs in Table 5, the combination of X_1 is in medium performance level and X_2 is in high performance level in the first group from 1st to 4th KSP. In the second group, from 5th to 7th KSP, the combination of X_1 is in high performance level and X_2 is in medium performance level. The same situation as third group, from 8th to 10th KSP, the combination of X_1 and X_2 are both in high performance level.
   (2) Examine all of these KFPs in Table 6, the combination of X_1 is in low performance level and X_2 is in medium performance level in the first group from 1st to 4th KFP. The second from 5th to 7th KFP, the KSFs of X_1 is in high and X_2 is in medium performance level.
5. *Specific items of KSFs combinations which causes to specific performance level in KSPs or KFPs.* This argument can be verified by examining the combination of X_1 and X_2 in Table 5 which needs to sustain above medium performance level, and at least one KSF maintain in high performance to achieve success outcomes.
6. *Very few KSFs combination leads to exceptional success outcome and very few KSFs combination leads to exceptional failure outcome.* The arguments can be supported in Tables 7 and 8.

Pursue success outcomes is a clear and firm goal for the entire company. To address this concern, the illustrations of adjustment process are based on the 10 KSPs in Tables 5, and 7 KFPs in Table 6. In summary, there are 3 KFPs have opportunities transformed into 3 KSPs.

The summary of transformation from KFPs into KSPs is presented in Table 9. For the first adjustment illustration, there needs to upgrade two items of KSFs for transforming with X_2 and X_4. The second adjustment illustration indicates that KSFs need to upgrade performance level with X_3 and X_2. The final adjustment illustration expresses that X_3 and X_4 are needs to reallocate performance level also.

Table 9 KSFs comparison among KFPs and KSPs

KSP/KFP	X_1	X_2	X_3	X_4	Cases	Out	Consistency
5th KFP	H	M	H	M	0	Failure	0.827586
8th SPK	H	H	H	H	0	Success	0.830508
6th KFP	H	M	M	H	0	Failure	0.827586
9th KSP	H	H	L	H	0	Success	0.772727
7th KFP	H	M	M	M	0	Failure	0.827586
7th KSP	H	M	H	L	0	Success	0.871795

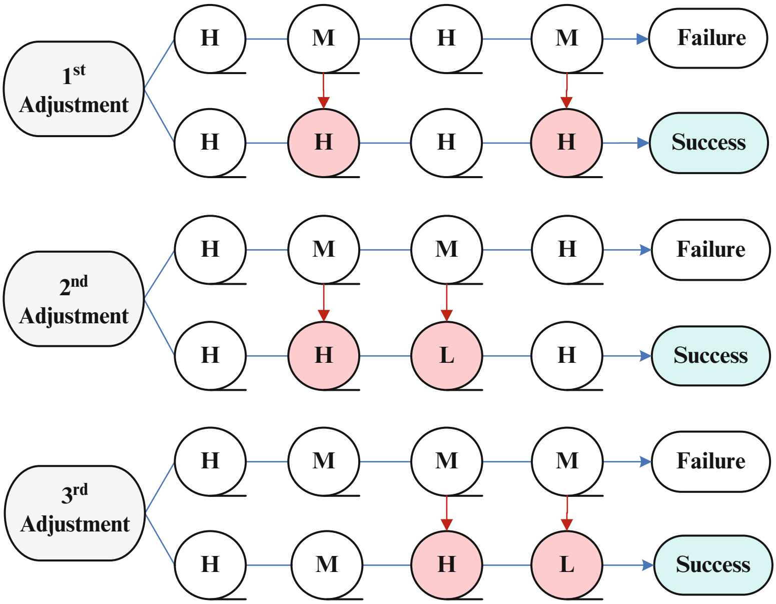

Fig. 4 Two-stage adjustment process flow

The Fig. 4 presents the adjustment flow chart for three adjustment process. The company upgrades KSFs based on the divergent competitive advantage of their own.

4 Discussion

The three research limitations in this paper are: (1) using simulated data for methodology illustration. (2) the study divides KSFs into three performance levels and divides operation outcomes into two subsets with fuzzy-set triangular range to calculate the fuzzy membership scores. (3) this paper selects four KSFs as illustration to explore KSPs/KFPs and provide two-stage adjustment rules. Defining different KSFs may lead to different causal relationships that may structure different KSPs/KFPs as well as the corresponding two-stage adjustment processes.

5 Conclusion

KSPs approach is applicable in many research disciplines, thereby enabling the identification of suitable KSFs combinations and accomplishing specific outcomes. There are always have KSPs guide businesses to pursue success outcomes that identifies the arguments from KSPs approach.

The outcomes are accomplished by combining multiple KSFs in different performance levels. The KSPs selection decision should be based on current competitive advantage of the business. More than one benchmarking path (e.g. all of KSFs are in high performance level) can be used in driving systematic strategy toward to success outcomes. The two-stage adjustment process provides dynamic concept to promote higher success probabilities and also to upraise profitability of company and industries as well.

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Part VI
Production Planning and Control

Modeling and Multiobjective Optimization for Energy-Aware Hybrid Flow Shop Scheduling

Ji-hong Yan, Fen-yang Zhang, Xin Li, Zi-mo Wang, and Wei Wang

Abstract In this paper, a multiobjective scheduling problem for energy-aware Hybrid Flow Shop (HFS) is studied, in which minimal makespan and energy consumption are set as the objectives. The energy consumption model of HFS is established, in which the energy consumption is categorized into five parts as Processing Energy (PE), Adjusting Energy (AE), Transport Energy (TE), Waiting Energy (WE) and Routine Energy (RE). Genetic Algorithm (GA) and Non-dominated Sorting Genetic Algorithm (NSGA-2) are applied to obtain optimal schedules. Simulation results demonstrate that the proposed method is effective in supporting energy efficiency management in HSF.

Keywords Energy consumption model • GA • Hybrid flow shop • NSGA-2

1 Introduction

Industry, which takes up to 33 % of worldwide primary energy consumption, has strong demands for energy efficiency management. In recent years, much research has been conducted on the analysis of manufacturing energy consumption. Statistical analysis approaches [1, 2], and intelligent algorithms such as fuzzy logic [3] and artificial neural networks [4, 5] are studied and utilized for energy evaluation to predict the energy consumption. However, energy consumption cannot be accurately formulated based on these approaches, which impedes their application in solving scheduling problem for Hybrid Flow Shop (HFS).

To overcome such disadvantage, Liu et al. developed an energy consumption evaluation model of HFS [6], in which energy consumption is divided by three

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operation steps: preparing, processing and adjusting energy. However, in practice, TE and WE, which are determined by the production schedule, have an important effect on energy consumption in HFS so that cannot be ignored.

In terms of scheduling optimization, Genetic Algorithm (GA) [7], Particle Swarm Optimization [8] and GT Algorithm [9] have been studied and employed to solve job shop scheduling problems in some research. However, most of the research concern with single objective, such as minimal makespan. Little research has been done on multiobjective scheduling problems.

In this paper, the energy consumption model of HSF is established, in which TE and WE are thoroughly studied. GA and NSGA-2 are employed to solve the multiobjective scheduling problem for HFS. A HFS scheduling problem is introduced and studied to validate the effectiveness of the proposed method.

2 Energy-Aware HFS Scheduling

2.1 HFS Scheduling Problem Formulation

As is shown in Fig. 1, the hybrid flow shop (HSP) consists of W processing stages with two or more parallel machines in each stage. There are n different jobs j_1, j_2, $\ldots$, j_n to be processed through W stages consecutively. M_k denotes kth parallel machine at a stage for $k = 1, 2, \ldots\ n$ where n_i presents the number of machines in stage s. The processing time of each job on each stage is fixed, whereas job sequence can be altered according to the schedule. Other assumptions are as follows:

1. All jobs are processed in same order.
2. Each job can be processed on each machine tool no more than once.
3. Each machine can process at most one job for each operation and cannot be interrupted during operations.

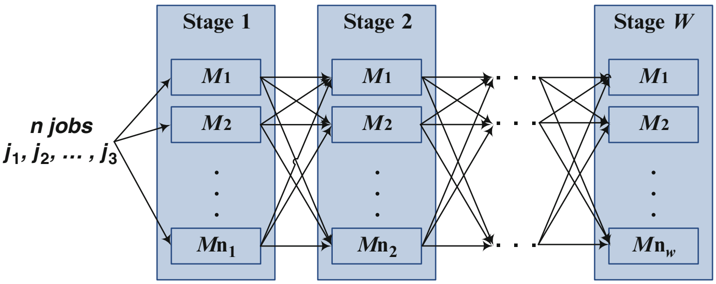

Fig. 1 Hybrid flow shop

4. Jobs are transported from one stage to the next by one transporting equipment following FCFS (First Come First Served) order. And the transportation route is determined by the schedule.
5. Each transporting equipment can transport at most one job and cannot be interrupted during transportation.

Given job j is the rth job on machine k, the time of job j arrived at stage s, $JA_{j,s}$, is calculated by (1).

$$JA_{j,s} = \begin{cases} F^k_{j,(s-1)} + TT_{k',k}; & r = 1; \\ \max\left\{F_{j,(s-1)}, JA_{j',s} + TT_{k'',k'}\right\} + TT_{k',k}; & r \geq 2. \end{cases} \tag{1}$$

where, $F^k_{j,s}$ denotes the finish time for the sth operation of job j in machine k. $TT_{k_i k_j}$ represents the time when the job is transported form machine k_i to machine k_j. k' is the number of machine on which the $(s-1)$th operation of job j is processed. k'' is the number of machine on which the sth operation of the job is processed which is the immediate predecessor transportation of job j.

Then, when sth operation of job j is the rth operation processed on machine k, the finish time of the sth operation of job j, $F^k_{j,s}$, the open time, $MO_{k,r}$, and the finish time, $MF_{k,r}$, of the rth job which is processed on machine k are calculated by (2), (3) and (4) respectively.

$$F^k_{j,s} = \begin{cases} JA_{j,s} + T_{j,k}; & r = 1; \\ \max\left\{MF_{k,(r-1)} + AT^k_{(r-1),r}, JA_{j,s}\right\} + T_{j,k}; & r \geq 2. \end{cases} \tag{2}$$

$$MO_{k,r} = \begin{cases} JA_{j,s}; & r = 1; \\ \max\left\{MF_{k,(r-1)} + AT^k_{(r-1),r}, JA_{j,s}\right\}; & r \geq 2. \end{cases} \tag{3}$$

$$MF_{k,r} = F^k_{j,s} \tag{4}$$

where, $T_{j,k}$ is the processing time of job j on machine k. $AT^k_{i,j}$ is the adjusting time of machine k from job i to job j.

Then the overall waiting time for machine k (WT_k) can be calculated by (5).

$$WT_k = \sum_{r=2}^{R} \left(MO_{k,r} - MF_{k,(r-1)}\right) \tag{5}$$

Finally, the time when all tasks have been finished, FT, can be calculated by (6).

$$FT = \max_{1 \leq j \leq n} F^k_{j,s} \tag{6}$$

2.2 Energy Consumption Model of HSF

In HSF, energy is consumed within a sequence of operations, which can be categorized into five parts as follows.

Processing Energy (*PE*) represents energy consumption for manufacturing, including the material removal, melting, vaporization and deformation, which can be calculated by (7).

$$PE = \sum T_{j,k} \cdot UPE_{j,k} \tag{7}$$

where, $UPE_{j,k}$ is the energy consumption per unit time when job j is processed on machine k.

Adjusting Energy (*AE*) is the energy consumed due to machine adjustment, which involves the replacement of fixture and cutting tool. It can be calculated by (8).

$$AE = \sum \sum AE^{k}_{r,(r+1)} \tag{8}$$

where, $AE^{k}_{r,(r+1)}$ denotes the energy consumed for adjusting from job r to job $(r+1)$ on machine k.

Transport Energy (*TE*) stands for the energy consumed when job is being transported, which can be calculated by (9).

$$TE = UTE \cdot \sum TT_{k_i,k_j} \tag{9}$$

where, UTE is the energy consumption per time when job is transported by transporting equipment.

Waiting energy (*WE*) defines the energy consumption when a machine is idle due to delay of job arrivals, which can be calculated by (10).

$$WE = \sum_{k=1}^{m} WE_k = \sum_{k=1}^{m} WT_k \cdot UWE_k \tag{10}$$

where, m is the total number of machines and UWE_k is the energy consumption per time when machine is waiting.

Routine Energy (*RE*) is defined as common energy consumed by activities including lighting, ventilation and heating, which is proportional to makespan and can be calculated by (11).

$$RE = URE \cdot FT \tag{11}$$

where, URE is the common energy consumption per unit time in job shop.

The overall energy consumption in job shop is calculated by (12).

$$SE = PE + AE + TE + WE + RE \tag{12}$$

3 Scheduling Optimization

3.1 Genetic Algorithm

The objective function of weighted sum GA is presented as (13) and (15).

$$FTValue = (FT - FT_{\min}) / (FT_{\max} - FT_{\min}) \tag{13}$$

$$SEValue = (SE - SE_{\min}) / (SE_{\max} - SE_{\min}) \tag{14}$$

$$\min(Fit) = \alpha_1 * FTValue + (1 - \alpha_1) * SEValue \tag{15}$$

where $FT_{\max}$ and $FT_{\min}$ are the maximum and minimum finishing time respectively. $SE_{\max}$ and $SE_{\min}$ are the maximum and minimum overall energy consumption respectively. α_1 reflects the significance of FT.

Operation-based encoding is employed in this paper. In the case of n jobs on m machines, each chromosome consists of $n \times m$ genes. The jth number i in the chromosome represents the jth operation of the job i. For example, as is shown in Fig. 2, the first gene "2" in chromosome denotes the first operation of job 2.

The two-point crossover operator [10] and the bit-flip mutation operator [11] are employed in this paper.

3.2 NSGA-2

Under GA with sum weights, an optimal solution is obtained by arbitrarily allocating weights to makespan and energy consumption. However, in practice, weights can hardly be determined accurately. Moreover, under fixed weights, some better solutions which can be obtained under approximate weights may be omitted. To solve this problem, NSGA-2 is employed in this paper [12, 13], in which elitism

Job	j_{21}	j_{11}	j_{12}	j_{22}	j_{31}	j_{32}	j_{13}	j_{23}	j_{33}	j_{34}	j_{24}	j_{14}
	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
chromosome	[2	1	1	2	3	3	1	2	3	3	2	1]

Fig. 2 An example of encoding

strategy and crowding distance comparison operator [14] are employed to maintain good genes, and keep the diversity of the population respectively.

Differing from the sum weighted method, NSGA-2 is based on comparison of Pareto. The Pareto-optimal mechanism and crowed-comparison operator are employed in non-dominated sorting selection to maintain the population. Under this method, a set of Pareto solutions can be obtained rather than an optimal one.

The NSGA-2, is employed to obtain Pareto solutions [15], In the non-dominated sorting procedure, individuals characterized as Pareto solution are assigned with front number 1. Other individuals only dominated by those with front number 1 are assigned with front number 2, and so on. After all individuals are ranked, fronts sets [F_1,F_2, ...,F_n] are generated, where F_i is the set of non-dominated solutions in the Pareto fronts.

In NSGA-2, the same encoding process, crossover and mutation operators as mentioned in the implementation of GA are applied.

The procedures of NSGA-2 are presented as follows.

Step 1. Initialize population P_0.
Step 2. Generate offspring population Q_0 through selection, crossover and mutation operators from parent P_0. A combined population $R_{\mathrm{i}} = P_{\mathrm{i}} \cup Q_{\mathrm{i}}$ is formed.
Step 3. Conduct non-dominated sorting procedure on the population R_{i}. All individuals are assigned with a front number, and front sets [F_1,F_2,...,F_{n}] are generated.
Step 4. Calculate crowding distance of each individual in each frontier set.
Step 5. Select N_{pop} individuals as the next generation of population $P_{\mathrm{i}+1}$ from R_{i} in elitism procedure. The selection scheme is demonstrated as follows: (1) If two individuals are from different frontier set, the individual with the lowest front number is selected. (2) If two individuals are in same front, the individual with the highest crowding distance is selected.
Step 6. Turn to Step 2 if iteration is not over.

4 Case Study

A HFS scheduling problem is introduced in this section, in which five different types of axis components are to be processed in four stages. Simulation parameters are presented in Tables 1, 2 and 3.

Table 1 The processing time of jobs T_{ij} (min)

Job \ Machine	1	2	3	4	5	6	7	8	9	10
1	5	4	6	4	12	3	4	3	5	7
2	5	5	3	3	6	7	8	4	10	9
3	2	3	5	4	6	1	3	8	7	6
4	8	2	3	10	9	10	9	4	8	6
5	10	10	9	5	3	9	14	4	6	9

Table 2 The transporting distance between machines TD_{ij} (m)

Machine \ Machine	1	2	3	4	5	6	7	8	9	10
1	0	1	2	6	8	2	6	7	8	4
2	2	0	2	6	6	7	2	1	3	2
3	3	2	0	4	2	3	4	3	1	2
4	1	3	1	0	5	7	6	8	4	2
5	5	3	2	1	0	4	2	6	4	5
6	1	2	3	5	1	0	6	7	6	8
7	2	2	2	2	7	2	0	1	6	2
8	3	2	1	5	1	4	5	0	6	7
9	3	2	1	2	3	4	5	1	0	2
10	2	1	3	1	2	1	1	3	5	0

Table 3 The machine id of each operation

Stage \ Job	1	2	3	4	5
1	2	2	1	1	3
2	5	4	5	4	4
3	6	8	8	7	6
4	9	10	9	9	10

Table 4 Results of three scheduling schemes

Scheduling scheme	Objective	Weight of makespan α_1	Makespan (*min*)	Total energy consumption (*kgce*)
Scheme 1	Minimal makespan	1	87	1,485
Scheme 2	Minimal energy	0	102	1,115
Scheme 3	Compromised solution	0.5	91	1,210

4.1 Simulation Results of GA

In the simulation, Population size, crossover, mutation rate and maximum number of iterations, are set as 50, 0.9, 0.01 and 200 respectively. Simulation is conducted under three sets of α_1 0, 0.5 and 1 respectively. The results are presented in Table 4.

When $\alpha_1 = 1$, the minimal makespan 87 min is obtained under scheme 1, whereas the energy consumption 1,485 kgce is the largest among the three schemes. On the contrary, when $\alpha_1 = 0$, the energy consumption is reduced by 370 kgce under scheme 2 compared with scheme 1, whereas the time duration, 102 min, is the longest among three schemes. To reach a relatively balanced schedule, scheme 3 is carried out, in which $\alpha_1 = 0.5$. The results show that the makespan is 11 min shorter than that of scheme 2, and the energy consumption is 275 kgce less than that of scheme 1.

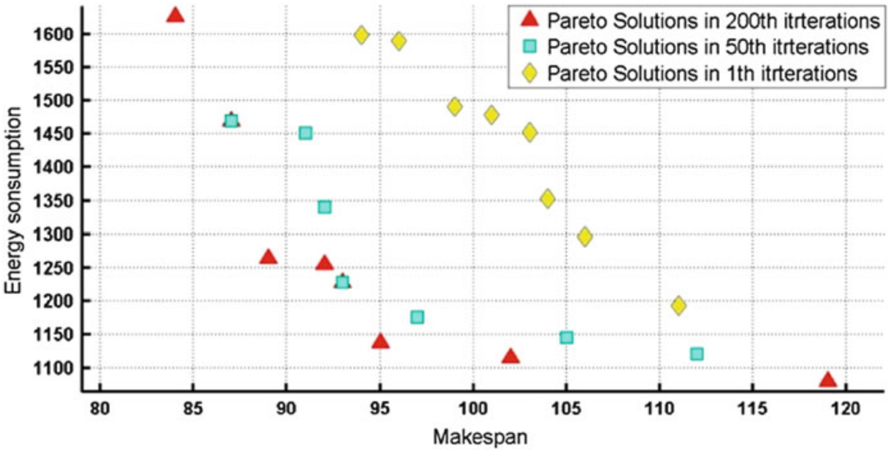

Fig. 3 Obtained Pareto optimal solution during 1th, 50th and 200th iteration for hybrid flow shop scheduling problem

Table 5 Pareto solution results of NSGA-2

Pareto Solution	1	2	3	4
Makespan (min)	84	87	89	92
Total energy consumption (kgce)	1,627	1,469	1,265	1,256
Pareto Solution	5	6	7	8
Makespan (*min*)	93	95	102	119
Total energy consumption (kgce)	1,228	1,138	1,115	1,080

4.2 Simulation Results of NSGA-2

In this simulation, population is set as 50 and maximum number of iterations is set as 200; crossover and mutation rates are set as 0.9 and 0.05 respectively.

From the Pareto solutions in 1th, 50th and 200th iteration (see Fig. 3), individuals of each generation approach towards optimal solutions. In the 200th iteration, eight Pareto optimal solutions are obtained (see Table 5).

As shown in Table 5, the Pareto solution 1 has the shortest makespan with 84 min, however the energy consumption with 1,627 kgce is the largest among the eight solutions. On the contrary, the minimal energy consumption 1,080 kgce is obtained in Pareto solution 8, whereas the makespan 119 min is the longest. From Pareto solution 1 to 8, the makespan getting longer, while the total energy consumption getting smaller.

The results of three scheduling schemes under GA are shown together with the Pareto optimal solutions in Fig. 4. According to the distribution of the results, both NSGA-2 and GA are both effective in multiobjective optimization.

Composition of energy consumption of each schedule is shown in Figs. 5 and 6. Based on the data obtained, analysis of energy consumptions on shop floor can

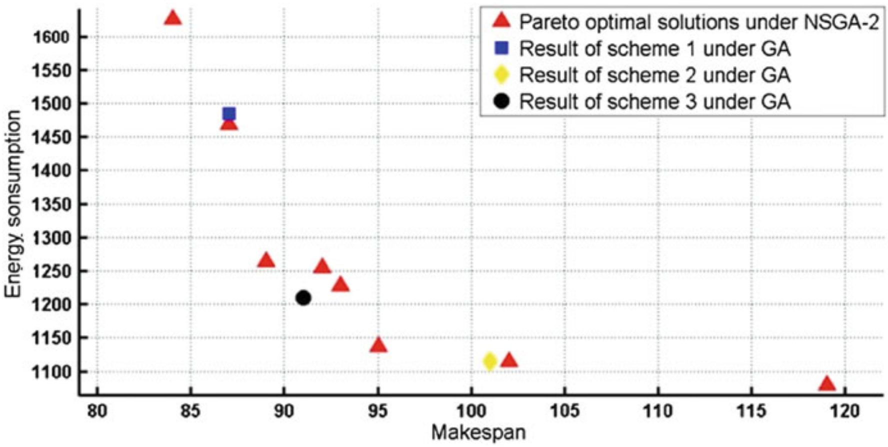

Fig. 4 Energy consumption of NSGA-2 results

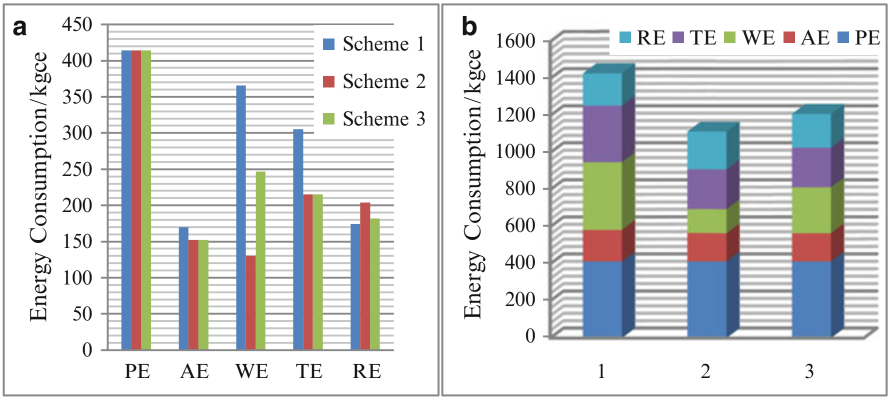

Fig. 5 Energy consumption under GA (**a**) Composition of energy consumption (**b**) Proportion of energy composition (Note: y axis is the energy consumption, using the unit as kgce; x axis of (**a**) presents the different compositions of energy consumption, namely PE, AE, WE, TE and RE, and x axis of (**b**) represents each scheme)

be conducted to facilitate the energy efficiency management. For example, from the result shown in Figs. 5 and 6, AE and RE are relatively stable under all the schedule, but WE and TE vary from one schedule to another.

Therefore, in this case, WE and TE are the major factors that impact the energy consumption on shop floor, which can be reduced through appropriate schedule. And thus the energy efficiency can be improved by taking investigation on the waiting and transporting process and corresponding maintenance actions and upgrading can be conducted accordingly.

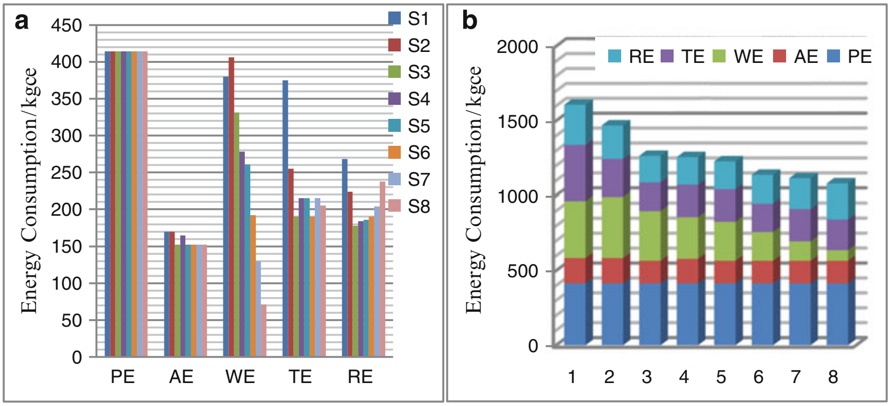

Fig. 6 Energy consumption of NSGA-2 results (**a**) Composition of energy consumption (**b**) Proportion of energy composition (Note: Sn, n = 1,2, . . . ,8, of (**a**) represents eight Pareto solutions. x axis of (**b**) represents number of each Pareto solution)

5 Conclusions

In this paper, the shop floor energy consumption model is established, in which the energy consumption in the manufacturing system is categorized into five parts, i.e. PE, AE, TE, WE and RE. Based on the proposed model, manufacturing managers are enabled to analysis the underlying problems in the system that escalate the energy consumption and corresponding measures can be taken to improve the energy efficiency.

NSGA-2 and GA with sum weights are employed to solve the multi-objective scheduling problem, and the case study verifies the effectiveness of the both algorithms. With GA, manufacturing managers are able to conduct appropriate production plans by adjusting the weights of the two criteria according to practical needs, while NSGA-2 provides manufacturing managers with a set of scheduling plans for selection that care for both makespan and energy consumption, which can facilitate the energy efficiency management in industrial practice.

In future work, the proposed method would be further studied with practical cases. And because of the effective application of the method for energy-aware HFS scheduling, more different job shop can be studied.

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Optimizing Six Sigma Processes to Satisfy Customers by TRIZ Innovation Methodology

Xin-jun Zhao and Ying Zhao

Abstract Product value attracts customers, product quality earns respect, and innovation makes your product distinct in the competition, charms the competitor's clientele, as well as maintain your own customer loyalty. The successful implementation of these three elements guarantees a bright future. Six Sigma is a structured quality improvement methodology that is based on data. Although it is great, there are also some bottlenecks during the performance of DMAIC. TRIZ is an inventive methodology that can make people more inventive and creative. By integrating the ideas of TRIZ into Six Sigma, the product can achieve a better quality, so that the company can survive in the highly competitive market. This paper firstly reviews TRIZ from the perspective of product/process creativity, innovation, and the traditional Six Sigma methodology – DMAIC, and then analyzes the necessity of integrating TRIZ into Six Sigma. Finally we sum up with how TRIZ is integrated into Six Sigma, and what can be achieved in this integrated process.

Keywords DMAIC • Integration • Six Sigma • TRIZ

1 Introduction of TRIZ

The definition of TRIZ (the acronym of the Russian words, and English translation is Theory of Inventive Problem Solving) is a human-oriented and knowledge-based systematic methodology for inventive problem solving [1, 2].

TRIZ was presented by Genrich Altshuller (Father of TRIZ) in the mid 1940s. He had published many books, technical publications before the late 1980s. Historically TRIZ was widely spread in Eastern Europe, particularly in the countries of the

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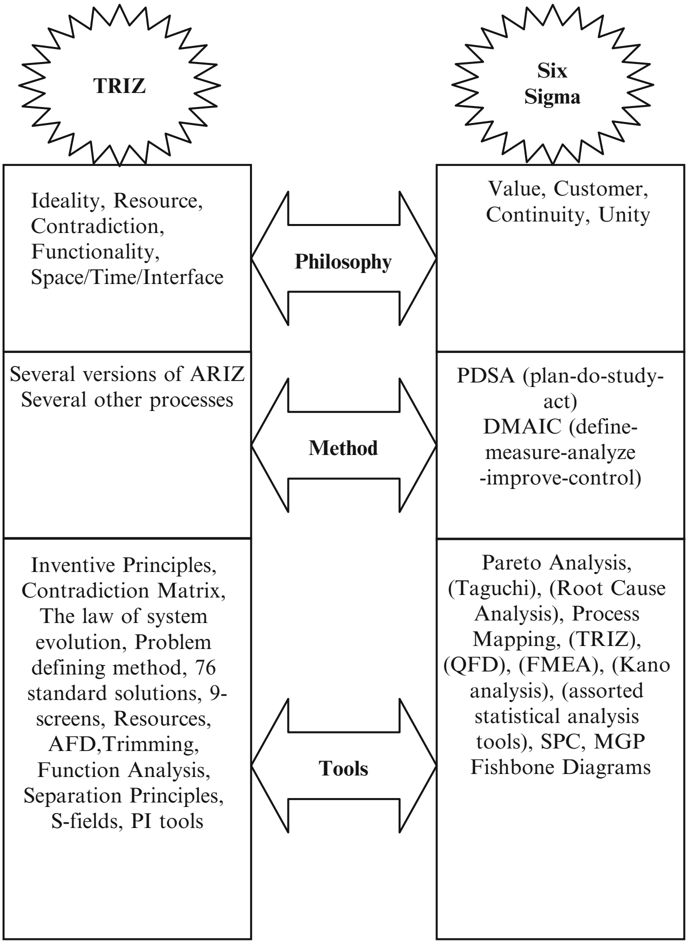

Fig. 1 The philosophy, method and tools of TRIZ and Six Sigma

former USSR. Since early 1970s it had been an important part of academic programs in many universities, colleges and schools [3]. Now more and more European, particularly German, universities that cooperated with industries successfully integrate TRIZ into the curriculum. Last year it had been successfully introduced in different industries, specifically in Pacific countries.

It is an established science, methodology, tool, and knowledge and model-based technology to stimulate and generate innovative ideas and solutions. The core of TRIZ is the law of system evolution [4–6]. The philosophy, method and main tools of TRIZ can be illustrated clearly in Fig. 1.

2 Introduction of Six Sigma and Its Job Plan (DMAIC)

Six Sigma is a structured methodology based on statistical data. Statisticians at Motorola developed this methodology in 1980s. Six Sigma regards all works in the production as a process. The quantity method is used to analyze which factors will affect the product quality in the process. After the critical factors are identified and improved, a higher customer satisfaction level can be achieved. The same pattern that is used to describe TRIZ in Fig. 1 is also applied to describing the philosophy, method and tools of Six Sigma. The bracketed content in 'Tools' level in Fig. 1 is the main tools that have been 'imported' into Six Sigma.

Continuously improved breakthrough pattern – DMAIC (Define, Measure, Analyze, Improve and Control) is the core of Six Sigma [7]. DMAIC goes through the following process: identify the problem, measure the current status, analyze where the problem is, improve the performance, and control the new process. The DMAIC flow in detail is illustrated in Fig. 2.

By applying DMAIC process, the quality of the product and the lever of customers' satisfaction will be improved [8], and the companies who use DMAIC will gain great profits.

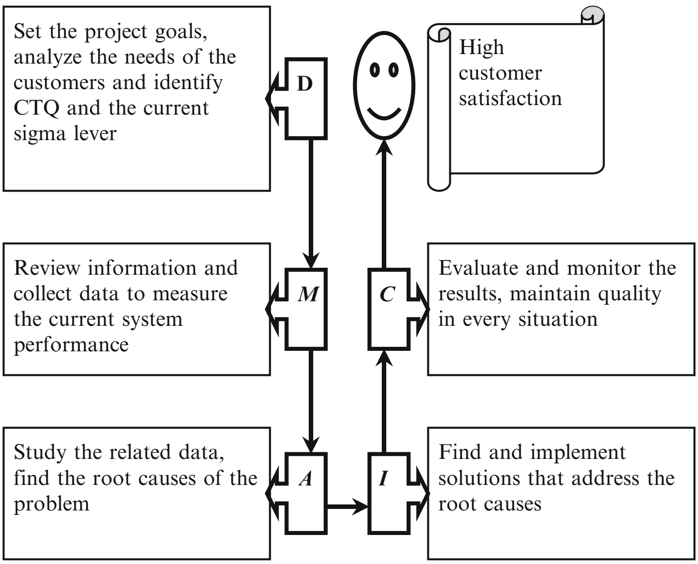

Fig. 2 Flow chart of DMAIC

3 The Necessity of Integrating TRIZ into Six Sigma

The philosophical principles of TRIZ and Six Sigma (see in Fig. 1) interact with each other.

1. The successful innovation better serves customers' requirements, with lower cost and less inconvenience.
2. The traditional method of TRIZ describes the evolution that happens in discontinuous bursts that are driven by market demands to a large extent [9].
3. One of the important philosophy principles of Six Sigma is to satisfy customers' requirements; TRIZ reflects the principle in terms of the functionality of product. The driving force for customers to buy a product is the function and features of the product, so enhancing the product's functionality will attract more customers.
4. It is possible to add value by enhancing functionality because value is the ratio of functionality to cost.
5. After a series of improvement, if the current system still cannot fulfill the function, it is considered that the function should be eliminated.

Based on the analysis above, the following conclusion can be achieved: TRIZ provides good ideas, but it lacks the environment to use, which means those good ideas cannot be embedded into the real business process. Fortunately Six Sigma provides the environment that TRIZ actually needs. Conversely, if the Six Sigma gets more innovations from TRIZ, the product will be more attractive and the company will get more profits from it.

Although Six Sigma is a great quality improvement method, it also has some disadvantages. The biggest disadvantage of Six Sigma is the delay usually existing in Six Sigma projects and intermediate deliveries, which result from decision-making errors leading to rework and time-consuming data collection activities [10]. Most of the traditional methods that are used in DMAIC, cannot solve this problem. The traditional methods and their limitations are listed in Table 1.

As far as many small and medium size companies are concerned, both the financial and human resources for Six Sigma are extremely limited [11]. If the wrong decisions are made at the beginning or the cycle time is too long, the losses of those companies will be large and even some of them will go under bankrupt. Therefore, the demand for more efficient analytical techniques and tools is obvious and urgent, which speeds up the decision-making activities, increases the productivity and innovative solutions through the processes of DMAIC, and reduces cycle time.

TRIZ has some powerful tools to help managers' engineers to avoid making wrong decisions, to find the inherent contradictions of the system, to take effective measures to solve them, and to decrease the cost and time of performing DMAIC.

Table 1 Traditional method of dmaic and their limitations

DMAIC process	Traditional methods	Limitations
Define	Flow diagram, Brainstorm, Conduct interviews, Circulate questionnaires, Hold group discussions with multiple customers	Lack of systematic method to define the problem; Lack of knowledge about the customers, customer requirements and problems; Cannot fulfill the exciting needs (future needs) of the customers
Measure	Conventional statistic methods, Computation of the process capability indices	Time-consuming data collection and measurements; Lack inventive and efficient way to measure the multiple systems
Analyze	Conventional statistic methods, Brain Storm, QFD	Lack of efficient tools to determine whether the current system should be redesigned or thoroughly abandoned
Improve	DOE (design of experiments), Conventional statistic methods	Lack of really productive and innovative ideas on improvements or competitive redesign; Time and labor consuming DOE; Hard to find the inherent contradictions and lack of solutions
Control	SPC (statistic process control), POKA-YOKA (the system preventing errors), pre-control of working procedure	Non-systematic approach and the failure of prediction

4 Enhance DMAIC Process with TRIZ Tools

TRIZ tools can help to solve Six Sigma bottlenecks. Compared with the traditional innovation or decision making techniques used in Six Sigma, TRIZ is much more different and efficient. TRIZ provides systematic and powerful set of analytical techniques and tools for both idea-collection and innovative idea-stimulation. Also it provides efficient tools for accelerating the steps of idea-generation process.

Table 2 lists the details of tools of TRIZ that can be applied to DMAIC processes.

5 Conclusion

Creativity and innovation are essential factors for business success. Today the major cause of lack of change is the reluctance to accept the good ideas in business. TRIZ is a powerful tool for innovation and creativity. It can help managers, designers and engineers to change the way of thinking and to look at the issues

Table 2 TRIZ tools used in each DMAIC process and their advantages

DMAIC process	TRIZ tools empowering the process	Advantages
Define	Problem definition tools, TRIZ technology forecasting	Provide a systematic method to define problems
		Identify the potential need of the customers
Measure	The class 4 of 76 standard solutions –measurement and detection standards	Provide some more inventive and efficient methods to measure, such as measuring a copy or an image, measure an introduced additive, using 2 detections instead of continuous measurement and so on
Analyze	Contradiction matrix, The law of system evolution	Simplify the complex relationships between the variables; find the crucial CQT and the ways to solve the problem by translating the inherent paradoxes to the system parameters in the contradiction matrix; look for the solutions from the contradiction table
		Identify whether the current system should be redesigned or thoroughly abandoned based on the law of system evolution
Improve	Inventive principles, 9-screens, the law of system evolution	Provide inventive ideas and methods to help the team group to avoid the old thinking ways;
		Simplify the method to predict the technology and operation of future system
Control	AFD (Anticipatory Failure Determination)	Thoroughly analyze the given failure mechanisms;
		Obtain an exhaustive set of potential failure "scenarios";
		Develop "inventive" solutions to prevent or minimize the impact of the failure

in a more innovative view. However, even the best invention or patent in the world cannot have a commercial success without a business environment. Six Sigma is a successful strategy management program, but it does not cover ideas innovation and generation. Additionally, there are some weak points of traditional Six Sigma methods. TRIZ methods and tools can improve Six Sigma methodology DMAIC, especially when Six Sigma methods and tools are not efficient and sufficient for some reasons. By integrating TRIZ innovation ideas into Six Sigma processes DMAIC, the following goals can be achieved: (1) increase effectiveness of Six Sigma deployments, especially in small and medium company; (2) reduce the life-cycle time and increase efficiency of using resources; (3) reduce or avoid "expensive" errors in decision making, especially in the definition process; (4) reduce the cost of rework due to the poor quality of Six Sigma.

In conclusion, many limitations of the traditional methods that are used in DMAIC can be overcome, and the most important thing is that the overall potential of Six Sigma in the improvement of business process is enhanced. There is no doubt that integration of TRIZ and Six Sigma methodology can decrease defect level, bring the companies more benefits, and make the customers more satisfied with the products.

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Data Mining Based Approach for Jobshop Scheduling

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Abstract In manufacturing system, there usually have been some unpredictable dynamic events, which would make the production scheme invalid. Therefore, it's necessary to inject some new vitality to traditional scheduling algorithms. To harness the power of complex real-world data in manufacturing processes, a jobshop scheduling algorithm basing on data mining technique is presented. This approach is explored in view of seeking knowledge that is assumed to be embedded in the historical production database. Under the proposed scheduling system framework, C4.5 program is used as a data mining algorithm for the induction of rule-set. A rule-based scheduling algorithm is elaborated on the basis of the elaborated data mining solutions. The objective is to explore the patterns in data generated by conventional intellectualized scheduling algorithm and hence to obtain a rule-set capable of approximating the efficient solutions in a dynamic job shop scheduling environment. Simulation results indicate the superiority of the suggested approach.

Keywords Data mining • Decision trees • Dispatching rules • Dynamic scheduling • Job shop scheduling

1 Introduction

Scheduling is a form of decision-making that plays a crucial role in manufacturing and production system [1]. Jobshop scheduling problem (JSP) is one of the most well known machine scheduling problems and it is a strongly NP-hard problem of

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combinatorial optimization [2]. The target of JSP is to allocate scarce resources, e.g. machines, to activities, e.g. jobs, with the objective of optimizing one or more performance criteria, such as minimizing makespan, flow time, lateness, tardiness, and et al. [3].

JSP problems investigated by researchers for several decades, and a lot of scheduling algorithms have been presented. Among them, rule-based scheduling algorithm provides a solution by the use of priority dispatching rules, aimed at selecting the next job to process from jobs awaiting service in queues. These rules are very simple heuristics providing approximate solution which are convenient to applied in manufacturing practice. However, they are performance-dependence on the state of the system and non-existence of any single rule, superior to all the others for all possible states of the system in [4].

In this paper, we propose an approach that seeks this scheduling knowledge through data mining module to identify a rule-set by exploring the existed production database, in order to get priority dispatching rules, aiming at selecting the next job to process from jobs awaiting service in queues. A set of best performing rules, under variety of system states, are taken as training examples to be input to the learning system. Intelligent decisions are then made in real time based on this knowledge. C4.5 program is used as a data mining algorithm for the induction of rule-set. It is applied to the issue about the machine selecting in the process conflict which need to solve. Finally, we compare and analyze the improved simulation results with the original conduct at the end of the paper.

2 Literature Review

Knowledge discovery can acquire useful knowledge from data; while the method of data mining is to obtain useful knowledge and is a specific step of knowledge discovery. Data mining is a blend of concepts and algorithms from machine learning, statistics, artificial intelligence, and data management and has been a rapidly expanding field with growing interests and importance and manufacturing is an application area where it can provide significant competitive advantage [5]. The use of data mining techniques in manufacturing began in the 1990s [6] and developments in data mining are generally directed at the refinement of algorithms and their application in manufacturing, their integration with existing systems, standardization, the use of common methods and tools, and the definition of repeatable projects. Currently, data mining technology has been applied in many areas, such as financial, biomedical, telecommunications industries and so on. In job shop scheduling system, there have accumulated a lot of production data, including information related to order, job, machine, WIP, as well as a great deal of other real-time information in the production processes. The scheduling decisions should be made on the complex mass of production information, not only real-time information but also historical data. There is also need to find correlations within the vast database on production information. From this point of view, data mining technology would stand out in production scheduling field.

Lee discussed and suggested several principles leading to a knowledge-based factory environment utilizing the data collected over several stages of the manufacturing-related processes [7]. Koonce et al. developed a software tool called DBMine using Bacons algorithm, decision trees, and DB learn, which applied data mining to assist engineers in understanding the behavior of industrial data and to find patterns in job shop scheduling sequences generated by a genetic algorithm [8]. Nhu Binh and Joe Cing made use of Geneti Programming for evolving effective composite dispatching rules for solving the Flexible JSSP with recirculation, with the objective of minimizing total tardiness [9]. L. Li et al. analyzed the differences and relations between traditional and data-based scheduling methods for complex manufacturing systems and then proposed a data-based scheduling framework [10].

Inductive learning in production scheduling has primarily been devoted to issues such as selecting the best dispatching rule using simulated data. Algorithms for constructing decision trees are among the most well known and widely used of all machine learning methods. Choi et al. used a decision-tree based method to find the knowledge for selecting dispatching rules from off-line data in a re-entrant manufacturing system, with consideration of its real-time state [11]. Among decision tree algorithms, J. Ross Quinlan's ID3 and its successor, C4.5, are probably the most popular in the machine learning community [12]. Piramuthu et al. proposed a mechanism to select among a given set of heuristics by using C4.5 algorithm for decision tree generation [13]. Li and Olafsson used decision-tree induction in his proposed approach to discover the key scheduling concepts by applying data mining techniques on historic scheduling data and to generate scheduling rules [14]. Priore et al. compared inductive learning based on C4.5 algorithm with other machine learning techniques for a selected flexible manufacturing system [15].

3 Proposed Approach

In modern manufacturing, the volume of data grows at an unprecedented rate. The collected manufacturing data contains valuable information and knowledge that could be integrated within the manufacturing system to improve decision making and enhance productivity. In this paper, a data mining based scheduling policy is present. The production scheduling decisions are made on either historical or real-time data, in order that the scheduling system would have high performance as well as preeminent ability to anticipate problems and deal with unpredictable events. Meanwhile, data from the shop floor could also be used as training samples or testing specimen for creating new rules or amending existing rules, especially when there are unpredicted dynamic changes in manufacturing processed. Thus, the scheduling rules are continuous updating to adapt to the changing environment.

3.1 Jobshop Data Characteristics Analyzing

Production scheduling is a typical knowledge-based decision-making process. So the data mining methods could be used as an effective tool to get needed training data from a large data based or data warehouse which full of production data, that fulfill previously unknown and potentially useful information related to historical or real-time state of production system, and then the discovered information or knowledge could be applied to the job shop production scheduling effectively.

In the production management information system, there usually accumulate a large number of production related data, such as job related data, device related data and so on. Data of production processes for scheduling have many differences characteristic compared to other industry data. The features are distributed as follows.

3.1.1 Diversity of the Production Data

Data, either the real-time data or the previous data, was the description or record of the system state or operating processes of a production system. The production scheduling data might come from different orders, different machines, different jobs, different operations, and even jobs' different process routes, so the production data for scheduling are abundant and complex. Due to the previously mentioned diversity source, these data can be of various types, may be all the data types of computer can express, include integer, boolean, char, text, and et al. Besides, the data storage modes using in production scheduling are different in different enterprises, as well as different factories or jobshops. Up till now, there is no uniform and widely accepted standard for production data description, so it is an arduous work to present the production data in a clearly and properly way. This means that, it is a very difficult task to discovery available knowledge from the enormous and complex production database.

3.1.2 Complexity of the Production Data

The complexity of the data derived not only from their diversity origin mentioned above, but also from some external factors, for instance, the multiple composition, the different expression means and so forth. Some data, in particular, are generated automatically by the computer system, while others are input manually by operators. These data could inevitably not keep the data information simple and clear, and would unavoidable bring more or less noises related to their sources and characteristics. These factors undoubtedly increased the complexity of the production scheduling data.

3.1.3 Concealment of the Production Data

The knowledge valuable for enterprises is usually hidden in the company's datasets. To raise appropriate scheduling knowledge or rules adapted to a particular manufacturing scene, the great concern for companies still is how to enable manufacturing engineers and managers to capture, transfer, extract, understand and use the knowledge from large amount of datasets. Critical scheduling-related knowledge may also be hidden in the databases. A typical example of such knowledge may be rules or relationships for dispatching a job to one of the available machines or for rescheduling an operation to another machine due to the machine original is going to break down. Sometimes, human operators may never find such rules by investigating a dataset manually. That means one may never be able to discover such hidden knowledge from a dataset without the assistance of computer-based data analysis and mining approaches.

3.2 Scheduling Framework with Data Mining

Conventional statistical data analysis methods are no longer the best alternative to be used for scheduling data, which have the characteristics of diversity, complexity and concealment. Data mining is an interdisciplinary field with the general goal of predicting outcomes and uncovering relationships in data.

There is often no inevitable or immediate association between production data and the scheduling rules; so the data mining module thereupon is used in the presented scheduling system. In the context of scheduling, one of primary responsibilities of data mining is to created available knowledge and rule, which focuses on predicting the behaviors of the production system and determining future schedule of WIP and machines on the shop floor, based on existing information from available production databases. Given this target concept, a data-mining-based scheduling system is proposed, and the overall framework is delineated in Fig. 1.

3.2.1 Data Source and Data Interface

Construction a proper training data set is a very crucial point in the entire data mining and knowledge discovery process. It is also a tough job. Data in the scheduling system are not independent; there are lots of related data in different information systems of a company, such as ERP, MES, and ACP. Meanwhile, historical data of scheduling results might be used as training data. These data can be classified into off- and on-line ones. The former include the information about production orders, jobs, machines and etc., while the latter are the real-time information reflecting the working condition of production environments, such as information about machine and job state.

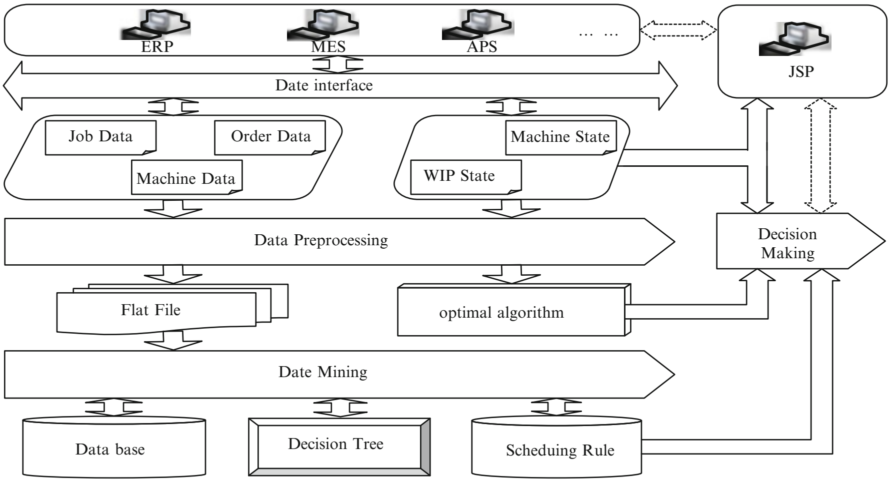

Fig. 1 The framework of shop scheduling system based on data mining technology

3.2.2 Data Preprocessing

Considerable amount of transformations are require before it is possible to mine any useful knowledge from the data obtain through the Data interface. Since these data are commonly incomplete and might contain noise, the preprocessing techniques are firstly required to execute filtration, purification, denoising and so on. Data preparation would make further efforts on aggregation, attribute construction, attribute selection, and so forth. Then these preprocessed data can be taken as study samples for data mining module to extract useful scheduling-relevant knowledge and rule.

3.2.3 Data Mining

The goals of data mining are to discover hidden patterns, associations, anomalies and/or structure from large amounts of data stored in a data warehouse, which can be achieved by using a variety of data mining tools and techniques. Here we focus on using decision trees and decision rules derived from such trees. C4.5 program is used as a data mining algorithm for the induction of rule-set in this paper. The decision trees have two functions. One is to predict which job should be dispatched first. The decision can be applied directly to jobshop or to be thought of as a new, previously unknown, dispatching rule. The other is to reveal insightful structural knowledge that can be used to further enhance the scheduling decision.

3.2.4 Scheduling Decision

Basic tasks of our data-based scheduling are as same as those of conventional scheduling, which deals with the allocation of resources to tasks over given time periods and the goal is to optimize one or more objectives. From the data mining perspective in jobshop scheduling, the main target is to determine which job should be dispatched first within a set of schedulable jobs at a particular instant on the specified machine. Extracting the knowledge and rule set through data mining module, the dispatching lists for any set of jobs would be created. Naturally, the scheduling decision module might integrate with some intelligent algorithms or optimal strategies to make the optimum or satisfaction solution.

3.3 Scheduling Strategy

There usually have inevitable unpredictable real-time events in real manufacturing systems which may cause a change in the scheduled plans, and make a previously feasible schedule to be infeasible when it is released to the shop floor. So the proposed scheduling strategy focuses on self-learning and self updating ability by making full use of the production data through data mining program.

3.3.1 Decision Tree

C4.5 program is used for constructing the decision tree. There are two major phases of the decision tree induction process: the growth phase and the pruning phase. The growth phase involves a recursive partitioning of the training data resulting in a decision tree such that either each leaf node is associated with a single class or further partitioning of the given leaf would result in at least its child nodes being below some specified threshold.

C4.5 uses an improved criterion for the best attribute selection and a more sophisticated method of probability estimation. The properties of the sample data would be sort to the nodes, while the root node is the property which has the largest amount of information among all of the samples. The intermediate nodes are those properties which have maximal information in the sub-tree samples set. The leaf node of each tree is the class value of the sample.

When test the sample set through decision tree, it will always meet problems. Different decision will make the test go to different branch; therefore the finally arrived leaf node will turn into the class of a new sample. This is the classification process. The structure of the decision tree is presented in Fig. 2.

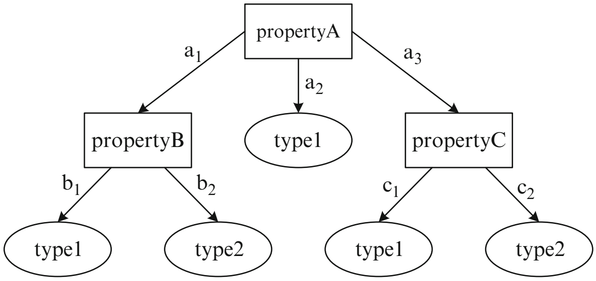

Fig. 2 The structure of the decision tree

3.3.2 Scheduling Algorithm

In this paper, decision trees are built to discovers scheduling knowledge from production data sets, and then priority rules can be raised to making scheduling decisions on the processing sequence of the workpiece.

A rule-based scheduling algorithm is proposed, where data mining technology is applied to discover knowledge and construct rules. The proposed algorithm produces priority dispatch rule to solve the scheduling problem, using data mining technology to obtain the processing sequence of the order and work piece. The schedule would be given on the basis of common rules in optimal scheduling and control, for example, the work orders which have the tightest delivery time and shortest processing time will be processed early. The process sequence of the orders that have different delivery time in the production plan will be recorded as historical data (off-line data) in details, and the sequence of the processes, when different type of work piece select a machine to process at the same time, will also be recorded. The purpose of data mining in scheduling is to extract efficient and effective rules in order to manage the production, even though there are conflict between production plan and the real state of jobshop.

In each iteration procedure, the algorithm considers the partition of the training set using the outcome of a discrete function of the input attributes. The selection of the most appropriate function is made according to some splitting measures. Now, let's make the following definition.

1. The remaining processing time. It's namely the total processing time for work piece residual process.
2. The delivery date. It's namely the deadline of the machining needs to be done.
3. Loose ratio. It's namely the ratio of delivery date and the remaining processing time. The looser the ratio, the less emergency the work piece is.

A data mining based scheduling algorithm is proposed including the following main steps (see Fig. 3).

Step1: To extract the data information and firstly to judge whether the delivery date is the same. If the delivery date is different, judging it. The work piece whose

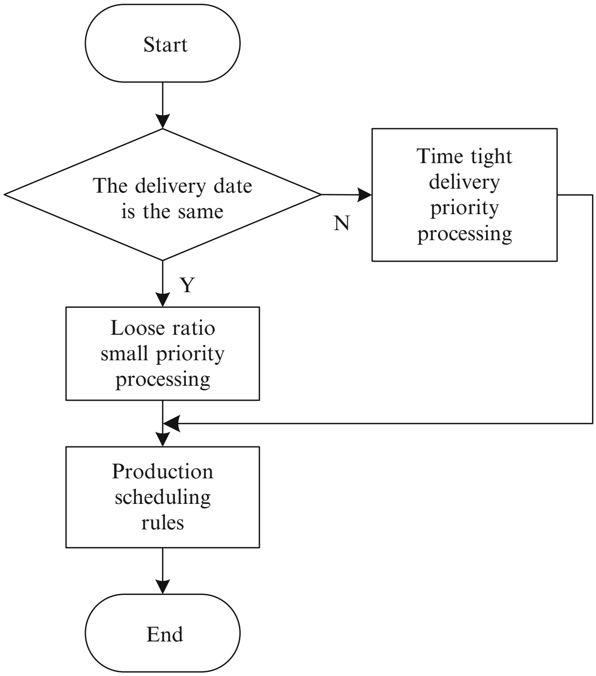

Fig. 3 Flow chart of the proposed algorithm

delivery time is tighter should be process in prior; if the delivery date of the two job are the same, then turn to the second step.

Step2: If the delivery date is the same, judging the loose ratio of the work piece. If the loose ratio is large, it shows that the work piece is not urgent and it has lower priority. The work piece that has smaller loose ratio should be process in prior.

Step3: Process the work piece according to the scheduling rules which are got from the data mining algorithm presented above.

4 Results and Discussion

This section aims to provide the summary of numerical simulation of the proposed algorithm. A simple production case with the data regarding the processing time of the problem are provided in Table 1.

According to the principle of the decision tree algorithm, we analysis the historical data and real-time data accumulated in the production and arrange suitable machine to process for work pieces. When different procedure of different work piece could process on one machine at the same time, the selecting pair of the machine and job will determine the scheduling results.

Table 1 Scheduling results

JOB	Machine and processing time				Due date
1	001	004	003	002	38
	3	4	6	3	
2	004	002	003	001	35
	4	5	5	3	

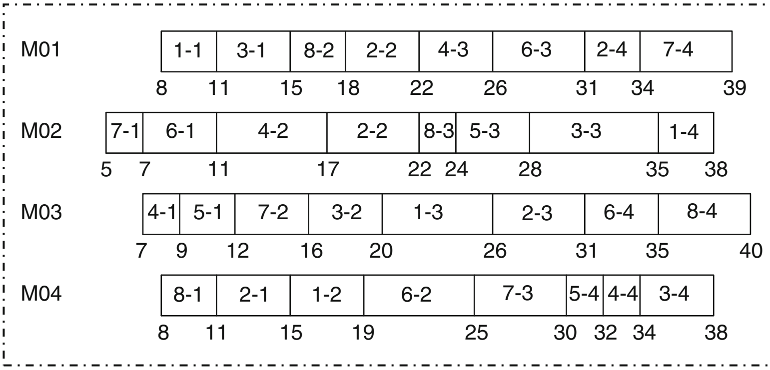

Fig. 4 Gantt chart of the simulation result

The simulation results (see Fig. 4) of the above case show that the dispatch of job's machining process has a great impact on the total processing time. Decision tree algorithm can discover useful knowledge and effective rule for scheduling, especially when there are conflicts between two jobs or two machines. The data processing and scheduling algorithm could integrated effectively to achieve the proposed shop scheduling system, which could efficiently reduce the processing time of the system and optimizes the job shop scheduling results.

5 Conclusion

The line of think of using data mining algorithm to get effective scheduling knowledge and rule to solve the complex scheduling problem is proposed. A data mining based scheduling framework in this way is presented where C4.5 program is used as a data mining algorithm for the induction of rule-set. Simulation related to some simple scheduling cases has been done, and the results shown the efficient and effective of our data mining based scheduling strategy.

There are several issues requiring further research and exploration. For example, the preprocessing of the data should be more detailed, the effectiveness of the data should be improved, and considering more constraints to optimize the scheduling results. Further, feature selection for different objectives and their combinations have to be explored in much more detail to obtain compact and efficient rule set.

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The Multilevel and Multiskill Labor Staffing and Scheduling Model for Data Entry Companies

Zheng Tan, Feng Wu, and Zheng-xiang Zhang

Abstract Data entry, one of the basic businesses in service outsourcing, depends much on human resources. The companies need to reasonably choose and arrange staffs in order to deliver data production in time. In consideration of production process and staff skill, a two-step multilevel multiskill labor staffing and scheduling model was built. The results of the proposed model with the data from the company ICP indicated the availability of the model, which can improve the vendors' capability and the significance of promoting development of the service outsourcing industry in China.

Keywords Labor staffing and scheduling • Linear programming • Multilevel • Multiskill

1 Introduction

Service outsourcing, an important part of high level modern service [1], is very important to industrial restructuring and promotion. The scope is widespread: hospital [2, 3], finance [4, 5], insurance [6], logistics [7] and so on. For the reason of fewer requirements to the staffs and low enter doorsill, the business is highly competitive and the profit space is limited [8]. Data entry outsourcing industry has the problem of the low staff utilization rate: the shortage/redundance of staffs in the program group are the common occurrence. The group has to temporarily transfer some staffs form other group or has no extra orders to distribute to the workers.

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Even worse, the group cannot deliver the qualified orders on schedule. The company has to pay hefty fines and lose customer trust. However, few studies focus on the operation system of data entry companies. Some papers mainly pay attention to clinical data collection and entry into the information system [9–11].

This paper studied the multilevel and multiskill staff scheduling problem in the data processing company. Depending on the mathematical model, the staff schedules can be generated which can help company deliver the data with low production cost in time.

2 Methodology

2.1 Problem Description

Data entry belongs to system operation service: it mainly process and integrates the data (including information) from bank, insurance and so on. The data processing process in the outsourcing company is shown in Fig. 1.

Segmental model derived from set-covering model proposed by Dantzig [12] and Edie [13] is one kind of developed mathematical model adopted by many researchers [14, 15] for labor staffing problem. Its Basic idea is deciding how shifts covered all the time intervals, then solve the staff demand problem in every time intervals to get the staff arrangement.

According to idea of segmental model, a two-step staff scheduling model, considered the whole data processing process in the outsourcing company was built with the unique constrains coming from the reality.

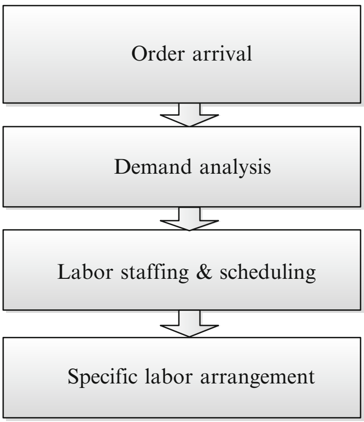

Fig. 1 Data entry process flowchart

2.2 Model Construction

Some terms are explained as follows:

Level of the order processing: the process of the data processing outsourcing business can be divided into three steps: classification, data entry and output. The original order should be transformed to final data product after several treatments. The order processed has transitivity in every level: the order processed in the previous level is the input in the next level.

Order type: the order type can be accepted by the operation system. Only with the same arrival time, delivery time and needed skill can two order be the same order type.

And the parameters used in the model can be seen as follows:

I: the set of the order type,
G: the vector of the arrival time of the order.
M: the vector indicates the number of the accepted order D: the vector indicates the delivering time of the order
F: the vector indicates the finishing time of the order
T: the vector indicates the processing time of the order
L: the vector of the loss when there is back order.
Z: the set of the staff skill
N: the vector of the number of the staff in every skill group
S: the set of skill type
Q: the set of the working shift
P: the set of the time interval
c_{i,q_v}: The cost of the type I order processed in the working shift q_v
$C_{I\times V}$: The vector indicates order-working shift cost
e_{i,p_u}: The cost of the type I order processed in time interval p_u:
$E_{I\times U}$: The vector indicated order- time interval cost
y_{i,p_u}: The staff number needed to process type I order.
Y: the matrix indicates the labor request consideration of the order type and time interval
X: the matrix indicates the staff scheduling consideration of the order type and working shift.

For the same type order, there is relationship between the staff demand in the time interval and the practical staff supply: $Y = X \times R$. When the skill s_j can cover the order; the number of the working staff in the skill group can be expressed as $\sum_{i\in J\otimes I} y_{i,p_u}$ $(\sum_{i\in J\otimes I} x_{i,q_v})$.

In this staff scheduling problem, the known condition included $O, S, T, N, R, M, D, P, Q, C, E, J\otimes I, q_v \supseteq p_u$ $(1 \le i \le I, 1 \le j \le J)$, we can make Y satisfy some requirements to solve X.

Step 1: labor scheduling problem

$$\min\left[\sum_{i=1}^{I}\sum_{u=g_i}^{V} e_{i,p_u} y_{i,p_u} + \sum_{i=1}^{I/2}\sum_{u=d_{i+I/2}}^{V}\left(l_{i+I/2}\frac{u-d_{i+I/2}}{t_{i+I/2}} y_{i+I/2,p_u}\right)\right] \tag{1}$$

Constrains:

$$y_{i,p_u} = 0, \quad \forall i \in [1, I], u \in [1, g_i] \tag{2}$$

$$\frac{d-g_i}{t_i}\sum_{u=g_i}^{d} y_{i,p_u} \le m_i \le \sum_{u=g_i}^{V}\left(\frac{u-g_i}{t_i} y_{i,p_u}\right), \quad i \in [1, I], d_i \le V \tag{3}$$

$$\sum_{\xi=g_{i+I/2}+1}^{u} \frac{p_\xi - p_{\xi-1}}{t_{i+I/2}} y_{i+I/2,p_\xi} \le \sum_{\Delta=g_i+1}^{u-t_{i+I/2}} \frac{p_\Delta - p_{\Delta-1}}{t_i} y_{i,p_\Delta}, \quad \forall i \in [1, I/2], u \in [g_i, V] \tag{4}$$

$$\sum_{i\in J'\otimes I} y_{i,p_u} \le n_{j'}, \quad \forall u \in [g_i, V], n_i \in N, i \in [1, I], j' \in [1, J] \tag{5}$$

$$\sum_{i\in J''\otimes I} y_{i,p_u} \le \sum_{j''} n_{j''}, \forall u \in [g_i, V], n_i \in N, i \in [1, I], j'' \in [1, J] \tag{6}$$

$$y_{i,p_u} \ge 0, y_{i,p_u} \in \mathbb{Z} \tag{7}$$

Constraint (2) ensures no staffs are assigned before orders arrival. Constraint (3) guarantees the number of order processed should be between processing ability and the number of the accepted order in the defined period. Constraint (4) indicates the processing sequence from level 1 to level 2: the number of the accumulated order in the level2 should be no more than that in the level 1 at any time; Constraint (5) indicates the number of the workers assigned for the order I should less than the number of the worker in the skill group at any time; Constraint (6) indicates the total number of the workers assigned for the order I should less than the total number of the worker from all skill group. Constraint (7) guarantees the number of the workers should be positive integer.

Step 2: labor staffing problem

$$\min\left[\sum_{i=1}^{I}\sum_{v=1}^{V} c_{i,q_v} x_{i,q_v} + \sum_{i=1}^{I/2}\sum_{v=d_{i+I/2}}^{V}\left(l_{d_{i+I/2}}\frac{v-d_{i+I/2}}{t_{i+I/2}} x_{i+I/2,q_v}\right)\right] \tag{8}$$

Constrains:

$$x_{i,q_v} = 0, \quad \forall i \in [1, I], v \in [1, g_i] \tag{9}$$

$$X \times A \geq Y,\ \ \forall u, v \in [1, V], \forall i \in [1, I], \sum_{v} \frac{v - g_i}{t_i} x_{i,q_v} < m_i \tag{10}$$

$$x_{i,q_{v+1}} = x_{i,q_{v+2}} = \cdots = x_{i,q_V} = 0,\ \ \forall i \in [1, I], \forall v \in [1, V], \sum_{v} \frac{v - g_i}{t_i} x_{i,q_v} \geq m_i \tag{11}$$

$$\sum_{\xi = g_{i+I/2}+1}^{u} \frac{q_\xi - q_{\xi-1}}{t_{i+I/2}} x_{i+I/2,p_\xi} \leq \sum_{\Delta = g_i+1}^{u - t_{i+I/2}} \frac{q_\Delta - q_{\Delta-1}}{t_i} x_{i,q_\Delta},\ \ \forall i \in [1, I], v \in [1, V] \tag{12}$$

$$\sum_{i \in J \otimes I} x_{i,q_v} \leq n_j,\ \ \forall q_v \in [1, V], n_i \in N, i \in [1, I], j' \in [1, J] \tag{13}$$

$$\sum_{i \in J \otimes I} x_{i,q_v} \leq \sum_{j''} n_{j''},\ \ \forall u \in [g_i, V], n_i \in N, i \in [1, I], j'' \in [1, J] \tag{14}$$

$$x_{i,q_v} \geq 0, x_{i,q_v} \in \mathbb{Z} \tag{15}$$

Equation (9) ensures no workers are arranged before order arrival. Constraint (10) indicates the worker assigned in every working shift should satisfy the labor demand solved in step 1. Constraint (11) expresses that no workers should be assigned to the working shift once the number of accumulated processed order has equaled to the total order demand (workers assigned in every working shift is more than that in the time intervals belonged to the working shift. The practical progress is faster than which described in the "labor scheduling model". So the labor staffing in the working shift needs to be stopped compulsively.). Constraint (12) indicates that the processing sequence should from level 1 to level 2, and the number of the accumulated order in level 2 should no more than that in level1 at any time; the formulation from (13), (14), (15) has the similar meaning as the formulation from (5), (6), (7).

3 Results

3.1 Model Input

The data collected for the model is from the company ICP founded in 2002. According to the field research, we choose the number of the arriving order in program A, B, C and VR in 1 day and the demand can be defined. The entry step can be simplified into two step; all the workers can be divided into four skill group: $Z = \{z_1, z_2, z_3, z_4\}$, four group respectively have 15, 15, 12 and 10 workers (Fig. 2).

The specific information of four programs can be seen in Tables 1 and 2.

Fig. 2 Correspondence of skill group and order type

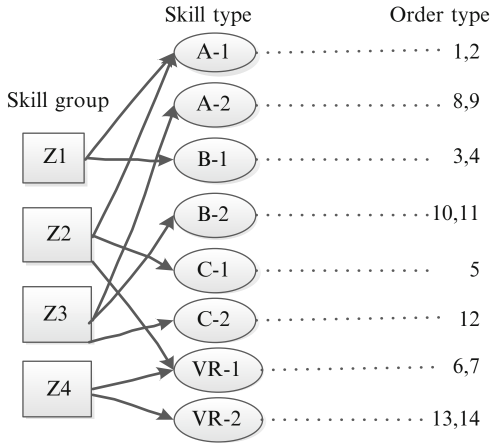

Table 1 Arrival time, delivery time and order amount

	Arrival time	Delivery time	Order received
A	8:30	18:00	286
	13:30	18:00	251
B	9:30	14:30	60
	14:30	9:30 next day	87
C	9:30	18:00	93
VR	8:30	11:30	50
	13:30	16:30	49

Table 2 Process time, labor and back order cost

Program	A		B		C		VR	
Level	1	2	1	2	1	2	1	2
Process time (min)	16	6	12	5	20	10	15	5
Normal labor cost (Yuan)	0.9	0.4	0.7	0.3	1	0.6	0.8	0.4
Overtime labor cost (Yuan)	1.8	0.8	1.4	0.6	2	1.2	1.6	0.8
Back order cost (Yuan)	2.5		2.8		2		3.5	

3.2 Mathematical Results

We solve the model by IBM ILOG CPLEX Optimization Studio12.3 and get the objective function value $f(x) = 287.9$ and the specific order-interval scheduling plan for the company ICP (see Table 3).

The above results are plugged into the 2nd step model and get the order-shift scheduling plan (see Table 4) with the total cost of 285.5.

Table 3 Order-interval staffing result

Order \ Interval	1	2	3	4	5	6	7	8	9	10
1	4	4	4	16	16	11	11	11	0	0
2	0	0	0	0	14	18	18	18	0	0
3	0	1	1	5	5	0	0	0	0	0
4	0	0	0	0	0	2	2	2	6	6
5	0	0	0	7	7	6	6	6	0	0
6	3	3	3	3	3	0	0	0	0	0
7	0	0	0	0	5	3	3	3	0	0
8	1	1	1	6	6	4	4	4	1	1
9	0	0	0	0	3	7	7	7	1	1
10	0	0	0	1	1	1	1	1	0	0
11	0	0	0	0	0	0	0	0	0	0
12	0	0	0	1	1	4	4	4	1	1
13	1	1	1	1	1	0	0	0	0	0
14	0	0	0	0	2	1	1	1	0	0

Table 4 Order-shift scheduling result

Order \ Shifts	1	2	3	4
1	4	16	11	0
2	0	14	18	0
3	6	0	0	0
4	0	0	2	6
5	0	14	1	0
6	3	3	0	0
7	0	14	0	0
8	1	6	4	0
9	0	3	7	0
10	1	1	0	0
11	0	0	0	0
12	0	1	4	1
13	1	1	0	0
14	0	2	1	0

4 Discussion

Order-shift scheduling plan is generated on the basis of order-interval plan. There are just some dedicate differences of the total cost between 1st step model and 2nd step model; order-shift scheduling plan emphasizes on the processing deadline so that there is no need to arrange staff when one kind of the order have been delivered to the customer. While some staff assigned to the shift cannot process the order before the orders arrive and they just make production preparation, for example debugging the computer or the work platform and rapid response to the orders arrived earlier. From the aspect of the company, the orders can also be postponed to the next shift with more staffs to finish them. We should consider this problem to decrease staffs' idle time and deliver the orders in time.

5 Conclusion

The multilevel, multiskill labor staffing and scheduling model is proposed from the aspect of the data processing company. The effectiveness of the model is confirmed by the empirical data from the company ICP. The main contributions of the paper are

A. The efficient operation system with low cost is very important for data processing companies. The core part is labor staffing and scheduling. Few studies focus on this kind of problem which the companies are eager to solve. This paper just makes up for the blank.
B. The two-step model is proposed under the condition of deterministic demand with multilevel and multiskill. It can be reduced to linear programming model which is finally solved by IBM ILOG CPLEX Optimization Studio12.3
C. The practical data collected from the company is used for the model. The result proves the validity of the scheduling model.

However, the model in this paper just considers two level processes. Actually the processes of data processing are more than two steps. Further research is needed to extend the model for more levels and balance the labor assignment between intervals and shifts.

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A Study for Correlate Impact of Risks in Large-Scale Equipment Tests Based on Structural Equation Modeling (SEM)

Chen Li and Fa-jie Wei

Abstract The hi-tech feature of large-scale equipment leads to the high probability and great impact of risks during equipment tests. In practical risk management, the risk events are usually dealt with as independent events. However, the risk events of different types are very likely to have correlate impacts, which will change the whole picture of risks in the test. In this article, the author introduces the concept of Structural Equation Modeling (SEM) to construct the correlate impact model of different types of risk events, and quantify the degree of influence of different types of risks by way of parameter estimation, so as to provide the basis for decision-making in risk response programs.

Keywords Correlate impact • Large-scale equipment test • Risk management • Structural Equation Modeling

1 Introduction

The equipment test is an important part of the equipment development, playing a significant role in deciding whether a type of equipment is qualified to be in production. The large-scale equipment, such as airplane, spacecraft, ship and bullet trains, have complicated structures and are multi-functioned, which makes them require higher standard of technical features and of precision in manufacture. High-tech means greater difficulty and higher risk. In the test any problem will have disastrous consequences, and therefore the risk management of large-scale equipment test has drawn special attention from people [1, 2].

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According to general risk management theories, to classify the risks based on the attribute of the risk events can help people understand the pattern of risk events, and then level up people's comprehensive security management [3, 4]. For instance, the causes of risk events can be classified as human factor, technic factor, management factor and environment factor; and the consequences of risk events can be the impact on the equipment's quality, the project's schedule, the cost, etc. In current risk management practices of large-scale equipment test, the identified risk events are usually dealt with as independent events, neglecting the correlate impacts between them [5, 6] Moreover, the current response programs are mainly designed for specific risk events which are of high probability and great damage, but the evolvement of the events are overlooked. In fact, the risk events of different types are closely related and very likely to have correlate impacts. Therefore, we should not only consider the coping strategy for one risk event when making risk decisions [7].

By analyzing the relationship between different types of risk events, people can effectively predict the correlate impacts among the events and avoid disastrous consequences by properly responsing. Some scholars have made researches on other areas in the field of risk management [8–11], and this article intends to, based on the classification of risk events, introduce the concept of Structural Equation Model (SEM), so as to find out a means to quantify the correlate impact of different types of risk events and solve practical problems.

The Structural Equation Modeling, proposed by Bock and Bargmann [12] in 1969, is a commonly used, main statistical modeling technique. It is more of a confirmatory technique than an exploratory one [13, 14]. The researchers apply the SEM to test the rationality of a specific model, rather than to find out a proper new one. They need to, based on their theoretical knowledge and former engineering experiences, evolve an initial model concerning the correlation of variables. There are various methods to set this model, and the most direct way is to describe the model with path diagram and then translate it into equations.

The SEM has a number of advantages:

1. It includes latent variables, and puts multiple latent variables and their representations into one model to analyze their structural relationships.
2. The SEM develops the advantage of path analysis, clarifying the complex relationships among variables. It also deduces the indirect effect and the total effect of variables.
3. It is a confirmatory analysis which follows the general linear model in multivariate analysis. The traditional statistical methods such as variance analysis, regression analysis, path analysis and factor analysis are included in the submodel of SEM, thus it has wider application [15, 16].

The second part of this article will explain the theory and method of SEM. Next in the third part the author will analyze the application of SEM in the model construction of correlate impact of risks in large-scale equipment tests. The fourth part is a case study, and in the end is the summary.

2 Theory and Method

There are two different kinds of variations in SEM. The first one is observed variable, or measured variable, which can be directly measured. The other one is latent variable, which can be shown only through associated observed variable. In SEM, it is usually assumed that the observed variables reveal latent variables. In addition, the latent variables are divided into endogenous latent variables and exogenous latent variables based on the character and relationship of those latent variables. Correspondingly the observed variables are also divided into endogenous ones and exogenous ones. Each SEM comprises two sub-models:

1. Measurement model, which describes the relationship between observed variables and latent variables.
2. Structural model, which describes the relationship among latent variables. Figure 1 is an example of SEM.

In Fig. 1, $x_1 \sim x_2, x_3 \sim x_5$ and $x_6 \sim x_7$ are three groups of exogenous observed variables, and their associated exogenous latent variables are ξ_1, ξ_2 and ξ_3; $y_1 \sim y_2$ and $y_3 \sim y_5$ are two groups of endogenous observed variables, and their associated endogenous latent variables are η_1 and η_2. These observed and latent variables constitute the measurement model, while ξ_1, ξ_2, ξ_3 and η_1, η_2 constitute the structural model. Moreover, $\delta_1 \sim \delta_7, \varepsilon_1 \sim \varepsilon_5$ represent measurement errors, and $\zeta_1 \sim \zeta_2$ are the error terms of the structural equation.

The relationship of variables in a SEM is supposed to be linear. A typical SEM is as follows:

Measurement model:

$$\boldsymbol{X} = \boldsymbol{\Lambda}_X \boldsymbol{\xi} + \boldsymbol{\delta} \tag{1}$$

$$\boldsymbol{Y} = \boldsymbol{\Lambda}_Y \boldsymbol{\eta} + \boldsymbol{\varepsilon} \tag{2}$$

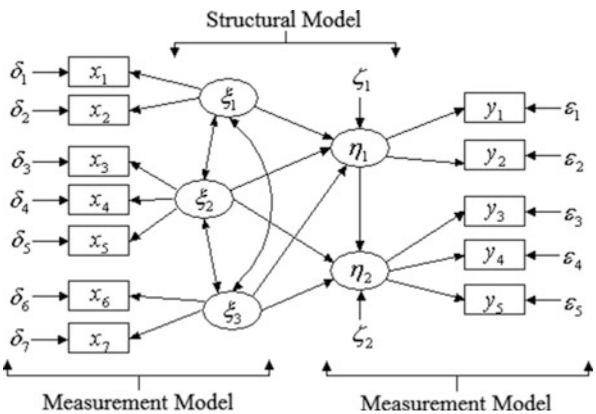

Fig. 1 Path diagram of common SEM

Structural model:

$$\boldsymbol{\eta} = \boldsymbol{B}\boldsymbol{\eta} + \boldsymbol{\Gamma}\boldsymbol{\xi} + \boldsymbol{\zeta} \tag{3}$$

In the above equations, $\boldsymbol{X}$ is a $p \times 1$ vector composed of p exogenous observed variables. $\boldsymbol{\xi}$ is a $m \times 1$ vector composed of m exogenous latent variables. $\boldsymbol{\Lambda}_X$ is a $p \times m$ loading matrix. $\boldsymbol{\delta}$ is a $p \times 1$ vector composed of p measuring errors. $\boldsymbol{Y}$ is a $q \times 1$ endogenous observed variable. $\boldsymbol{\eta}$ is a $n \times 1$ vector composed of n endogenous latent variables. $\boldsymbol{\Lambda}_Y$ is a $q \times n$ loading matrix. $\boldsymbol{\varepsilon}$ is a $q \times 1$ vector composed of q measuring errors. $\boldsymbol{B}$ is a $n \times n$ coefficient matrix, describing the relationships among endogenous latent variables. $\boldsymbol{\Gamma}$ is a $n \times m$ coefficient matrix, describing the effect the exogenous latent variable $\boldsymbol{\xi}$ has on the endogenous latent variable $\boldsymbol{\eta}$. $\boldsymbol{\zeta}$ is a $n \times 1$ vector composed of n explicable errors.

The Partial Least Square Path Modeling and the Linear Structural Relationships (LISREL) are the two most frequently used methods to do the parameter estimation for a SEM. After the estimation of parameters, people need to assess the model by Chi-Square, Normed Fit Index (NFI), Non-Normed Fit Index (NNFI), and Comparative Fit Index (CFI). If the initial model does not conform to the observed data, it is necessary to modify the model and test it again with same observed data.

3 Model of Correlate Impact of Risk Events Based on SEM

We make the following assumptions in the risk management of large-scale equipment tests:

1. A risk event belongs to only one type of risk;
2. Products of same model or series are recognized with similar risk events in each test;
3. All possible risk events have been recognized before the test, and we do not consider new events.

The correlate impact of different types of risk events are embodied in the probability of their occurrence. The occurrence, elimination or the change of probability of one type of risk events will affect the probability of another type, and the same type of events may also be affected. The SEM makes it possible to construct the correlate impact of one risk event with others, so people are able to know the correlate impact of all types of risk events.

We set up a new concept – risk type index – to describe the degree of importance of a type of risk. When making the risk assessment, the probability of a certain risk event can be subjectively judged, while the correlate impact of risks and their risk type index are difficult to directly assess. It can only be analyzed qualitatively. In a SEM, we define the probability of recognized risk events as observed variables, and the risk type indexes as latent variables.

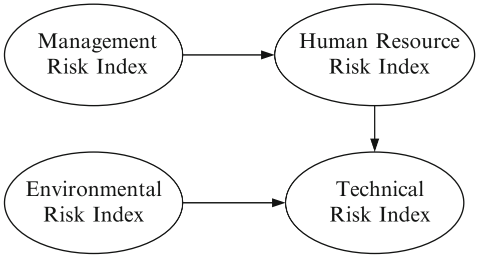

Fig. 2 Path diagram of correlation of risk types

The environmental risk, technical risk, management risk and human resource risk are four common types of risks. Based on the objective facts and the experience of experts, we make the following assumptions: the level of management will affect the human resource ability; the change of test environment and human resource will affect the reliability and stability of equipment technology. Figure 2 shows their relationships.

The environmental risk index (ERI) and the management risk index (MRI) are exogenous latent variables, and their corresponding probability of risk events are exogenous observed variables. The human resource risk index (HRRI) and the technical risk index (TRI) are endogenous latent variables, and their corresponding probability of risk events are endogenous observed variables.

When doing the same test, the complex equipments of the same type encounter similar risk events. Therefore, the assessment of risk events by experts in each test can serve as a sample, and people use these samples to train the model, so as to get the index of correlate impact of risks for a certain type of complex equipment test.

4 Case Study

Sixty tests are carried out by a type of equipment, and their recognized risks are roughly the same. Now we choose 17 representative risk events. In each test ten experts will assess the risks, and their assessments will be calculated by the method of weighted mean. R_i means the assessment of ith risk event in a test. $R_1 \sim R_4$ are management risks, $R_5 \sim R_8$ are environmental risks, $R_9 \sim R_{13}$ are human resource risks, $R_{14} \sim R_{17}$ are technical risks.

Before setting up the structural model, one should make the factor analysis on risk events, calculate correlation coefficient matrix, and use LISREL software to do the structural equation modeling, combining the structural model proposed earlier. Figure 3 shows the result model of correlate impact of risks.

The test results are shown in Table 1, which indicate that the model can reflect the relationships of data quite accurately.

The results show that the correlate impact of different types of risks exists, and the human resource risk is highly correlated with the technical risks, which conforms to the reality.

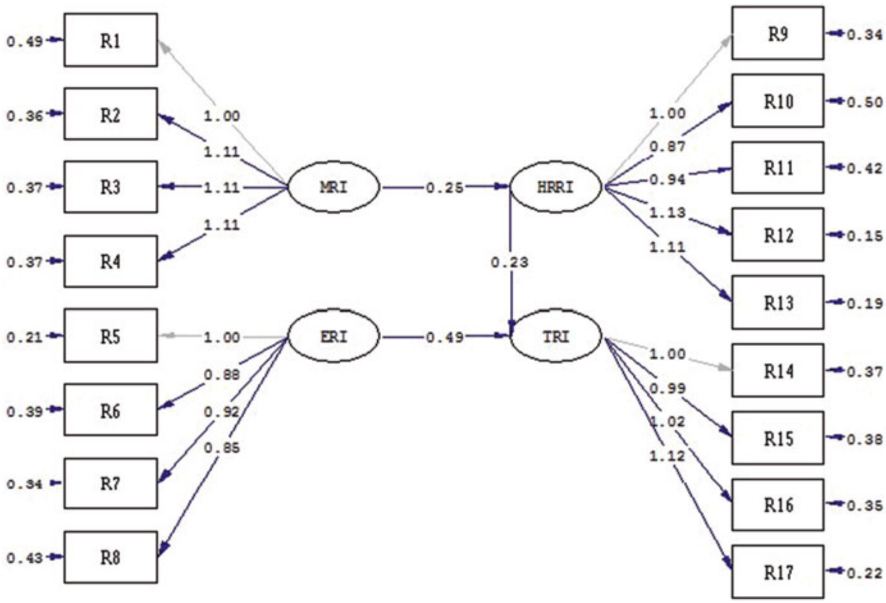

Fig. 3 Model of correlate impact of risks based on SEM

Table 1 Assumptive test result

Index	Chi-Square	NFI	NNFI	CFI
Data	154.01	0.89	0.96	0.97

5 Conclusion

Through SEM, the correlate impact of risks in large-scale equipment tests can by quantified for people to get the specific influence coefficient. In practical applications of SEM, people can not only judge the main sources and content of risks according to the degree of correlate impact of risks, and design the appropriate risk response programs; they can also develop it in the following three aspects.

1. To follow and predict a certain risk event. When its probability increases, people can predict the probability of other risk events.
2. To make risk correlate impact assessment for different agencies and in different testing stages, which will provide the decision basis for agencies to formulate risk management strategies in equipment tests.
3. If the SEM incorporate the degree and the types of damages of risk events as variables, their correlate impacts can also be discovered, which will provide the decision basis for risk management from another approach.

The correlate impact analysis of risks in large-scale equipment tests based on SEM is of great significance to risk management. In the future researches, we will further improve the method so as to make better use of it in practice.

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Research on Construction Risk of Real Estate Based on Factorial Analysis

Wen-jie Hu and Xing Bi

Abstract Real estate is the leading industry in China's national economic system, but this industry is facing a lot of risk, especially during the construction stage. It is a key monitoring object of the relevant units because of its large investment and long period. This thesis identifies and evaluates the non-systematic risk during the estate construction phase based on the factor analysis, then finds the key risk factors and how great they can influent the object, finally gives the comprehensive risk value of construction stage and provides certain reference to relevant units for risk management.

Keywords Factor analysis • Project construction • Real estate • Risk

1 Introduction

The real estate belongs to the guiding, basic industry in China's national economic system and it is becoming a pillar industry because of its strong industrial relevancy and leading ability. In recent years, with continuous deepening of economic restructuring in the cities, the real estate market is also showing a good development trend [1].

But it is well known that the real estate project faces great risks. In terms of the construction stage, this stage needs massive funds, great time and involves complicated and numerous risk factors which can cause absolutely different and serious consequences [2]. Whether the project can get expected results is great uncertain. Therefore, it is necessary to adopt scientific method to identify and analysis the risk factors in this phase.

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2 Methodology

The basic idea of factor analysis is investigating the internal structure of correlation coefficient matrix or covariance matrix then finding a few random variables that can control all variables and describe the relationship between multiple variables [3]. Furthermore separate variables into different groups according to the correlation between the variable, as a consequent, in the same group the correlation between variables becomes higher and in different groups becomes lower. Variables in each group represent a basic structure, and the basic structure is called public factor or the main factor. In economic statistics, finding out a few main factors from intricate economic phenomena is important so that we can analysis and interpret complex economic problems [4, 5].

Domestic and foreign scholars have gained a certain amount of research achievements about evaluating estate risk [6, 7]. But for the construction phase, present method is not adequate and effective enough. Specialized and systematic risk management method is deficient. Therefore, based on the method of factor analysis, from the angle of substantial study, through questionnaire, expert estimation and SPSS software, this paper finds the key risk factors and how much they can influent the object, finally scores the comprehensive risk value of estate construction and provides certain reference to relevant units for risk management.

This questionnaire is mainly divided into two parts: one is the basic information about the respondents; the other is the scores of risk factors during construction stage as well as some other suggestions. The first part is used to get knowledge of the respondents' working unit and position. The second part contains 17 risk factors, inviting relevant personnel or experts score on risk factors, the scores have five levels: 5 for great, 4, 3 for regular, 2 for small, 1 for minimal.

On the basis of the questionnaire, we use SPSS18 process data by the method of factor analysis. First we use the principal component analysis extract six common factors, then rotate factor matrix through maximum variance cross rotation method for the purpose of explaining the common factors. As a result, comprehensive risk factors during construction stage can be extracted as well as how great their influences are can be known. The specific processes are as follows.

3 Analyze Risk Factor of Estate Construction Phase

There are many risk factors influence construction phase of real estate project. According to whether can be avoided, they separate in two parts, namely system risk and unsystematic risk. The former is unavoidable and impacts all items on the market, including force majeure risk, the natural environment risk, legal risk, political risk, economic risk and so on. The later only effects individual project and can be eliminated though improving management or technology [8].

Table 1 The table of risk during construction phase

Number	Risk factor
X1	The financial difficulty
X2	Imperfect drawings or data
X3	Construction errors
X4	Clarification or answer questions not timely
X5	Imperfect progress schedule
X6	Inappropriate monitoring
X7	Lack correcting capability
X8	Improper use of equipment and materials
X9	Lack of skilled constructors
X10	Imperfect procurement contract
X11	Inappropriate budget
X12	Change and claim
X13	Improper design
X14	Inappropriate construction technology
X15	Inappropriate construction scheme
X16	Lack of quality assurance system
X17	Unskilled supervision personnel

Because the system risk is unavoidable and cannot be eliminated though improving management or technology, this thesis only focuses on unsystematic risk. With reference to domestic and international relevant researches [9–11] the table of risk during construction phase is got, such as Table 1.

4 Analyze Investigation Dates

There are three steps in this part, namely extracting the common factors, denominating the common factor and evaluating factor score. Through this part, key risk factors and their scores can be got, and the whole project's risk value can be known. Finally, measures can be taken to manage the risks.

4.1 Extract the Common Factors

In Table 2, the first column is the number of each factor. The second column is the characteristic value in the correlation coefficient matrix and it contains three parts: the first part is characteristic value for each component, arranging from big to small; the second is the proportion of variance in the whole which is interpreted by each component; the third is the cumulative proportion of variance interpreted by each component. The third column is the factor extraction results, namely factor loading

Table 2 Total variance interpretation scale

Original	Initial Eigenvalues			Extraction sums of squared loading			Rotation sums of squared loading		
Factor	Total	% of variance	Cumulative%	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	3.678	33.116	33.116	3.678	33.116	33.116	2.333	21.003	21.003
2	2.083	18.752	51.868	2.083	18.752	51.868	1.515	13.639	34.643
3	1.285	11.567	63.436	1.285	11.567	63.436	1.233	11.103	45.745
4	1.004	9.036	72.471	1.004	9.036	72.471	1.381	12.429	58.174
5	0.773	6.958	79.429	0.773	6.958	79.429	1.629	14.665	72.839
6	0.535	4.817	84.247	0.535	4.817	84.247	1.267	11.407	84.247
7	0.429	3.86	88.107						
8	0.355	3.195	91.302						
9	0.282	2.539	93.84						
10	0.223	2.004	95.845						
11	0.154	1.386	97.231						
12	0.114	1.025	98.256						
13	0.074	0.664	98.92						
14	0.054	0.49	99.41						
15	0.043	0.387	99.797						
16	0.02	0.183	99.979						
17	0.002	0.021	100						

Rescaling	Initial Eigenvalues			Extraction sums of squared loading			Rotation sums of squared loading		
Factor	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	3.678	33.116	33.116	5.502	32.363	32.363	3.997	23.515	23.515
2	2.083	18.752	51.868	3.007	17.691	50.054	2.256	13.272	36.787
3	1.285	11.567	63.436	1.749	10.289	60.343	2.143	12.606	49.393
4	1.004	9.036	72.471	1.681	9.888	70.231	2.006	11.798	61.191
5	0.773	6.958	79.429	1.183	6.956	77.187	1.997	11.746	72.937
6	0.535	4.817	84.247	0.765	4.499	81.686	1.487	8.749	81.686
7	0.429	3.86	88.107						
8	0.355	3.195	91.302						
9	0.282	2.539	93.84						
10	0.223	2.004	95.845						
11	0.154	1.386	97.231						
12	0.114	1.025	98.256						
13	0.074	0.664	98.92						
14	0.054	0.49	99.41						
15	0.043	0.387	99.797						
16	0.02	0.183	99.979						
17	0.002	0.021	100						

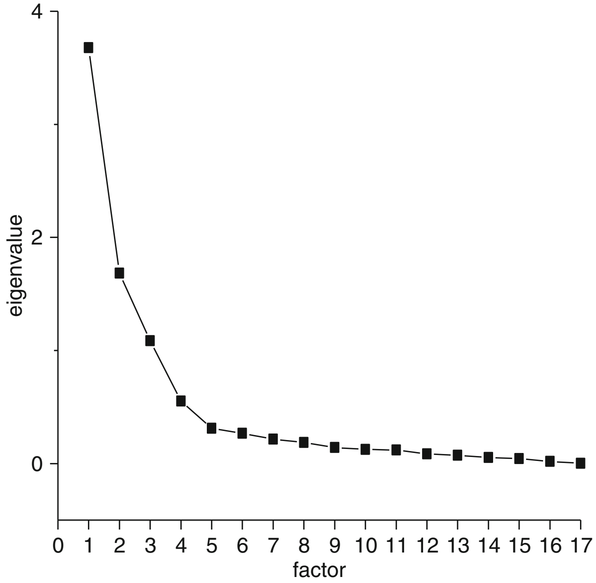

Fig. 1 Scree plot

without rotation, which contains characteristic value of each factor, the percentage of the variance in the whole and the cumulative percentage. The last column is factor extraction results after rotation.

Look at the factor contribution rate in Table 2 namely total variance interpretation table, the former six factors explain 84.247 % of the cumulative variance contribution, which shows that the six factors integrate 84.247 % of the original 17 factors [12]. They can basically reflect the nature information of the sample.

By the lithotripsy figure (Fig. 1), we can see that the first six characteristic values are bigger and the factor characteristic value curve becomes flat from the seventh factor, so extracting six common factors is appropriate. Factor analysis plays a role of reducing dimension and reducing data. On the premise of rarely information loss, the original 17 risk factors turn into six common factors.

In order to reflect the relationship between variables more clearly, do maximum variance cross rotation to make each variable has a high load on the six common factors, thus gaining the factor loading matrix [13], as is shown in Table 3, namely factor loading matrix after rotation. The matrix shows how much every variable load on the six public factors, so that the meaning of the six common factors can be clarified, ideal public risk factor model can be got, and further more key risk factors appear.

Table 3 Factor loading matrix after rotation

	Original						Rescaling					
Variance	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
X9	0.56	−0.107	−0.01	0.116	0.008	0.133	0.849	−0.163	−0.014	0.177	0.013	0.203
X14	0.7	0.333	0.032	0237	0.233	0.098	0.828	0.391	0.038	0	0.274	0.116
X15	0.59	0.116	0.038	0.143	0.044	−0.03	0.823	0.162	0.052	0.2	0.061	−0.04
X16	0.52	−0.03	0.051	0.475	0.162	−0.05	0.63	−0.037	0.063	0.579	0.197	−0.06
X3	0.42	0.406	0.256	0.19	0.283	0.203	0.51	0.492	0.31	0.23	0.342	0.245
X17	0.28	−0.101	0.171	−0.13	−0.174	−0.2	0.452	−0.164	0.279	−0.21	−0.28	−0.32
X1	0.02	0.63	0.14	−0.02	0.003	0.124	0.026	0.801	0.178	−0.02	0.004	0.158
X13	0.16	0.596	0.042	0.179	0.417	0.042	0.184	0.7	0.05	0.21	0.489	0.049
X6	0.26	−0.419	0.388	0.232	−0.007	−0.28	0.329	−0.531	0.493	0.294	−0.01	−0.36
X8	−0.1	0.178	0.567	0.033	−0.031	−0.03	−0.106	0.261	0.833	0.048	−0.05	−0.05
X7	0.53	−0.157	0.536	0.067	0.067	−0.04	0.643	−0.191	0.649	0.082	0.081	−0.05
X4	0.35	0.129	0.413	0.141	0.168	−0.13	0.498	0.185	0.593	0.203	0.241	−0.19
X10	−0	0.267	0.309	0.724	−0.035	0.029	−0.01	0.305	0.353	0.828	−0.04	0.033
X12	0.29	−0.146	−0.08	0.633	−0.014	0.182	0.359	−0.18	−0.098	0.779	−0.02	0.223
X2	−0	0.2	0.215	−0.06	0.977	0.358	−0.026	0.183	0.197	−0.06	0.892	0.327
X5	0.19	0.005	−0.1	0.01	0.522	−0.2	0.271	0.008	−0.139	0.015	0.76	−0.29
X11	0.19	0.264	−0.16	0.164	0.021	0.916	0.186	0.263	−0.156	0.164	0.021	0.912

Table 4 Factor score's matrix

Variance	Factors 1	2	3	4	5	6
X1	.000	.423	.068	−.068	−.164	−.058
X2	−.221	−.295	.263	−.095	.741	.335
X3	.094	.159	.105	−.010	.013	.057
X4	.052	.046	.184	−.010	.017	−.072
X5	.042	−.020	−.202	.043	.299	−.232
X6	.013	−.282	.238	.099	.058	−.032
X7	.158	−.202	.400	−.158	−.034	.157
X8	−.108	.059	.410	−.048	−.089	.074
X9	.202	−.099	−.051	−.047	−.035	.098
X10	−.236	.168	.135	.557	−.070	−.086
X11	.068	−.113	.061	−.040	−.160	.836
X12	.004	−.165	−.152	.424	.024	.086
X13	−.011	.381	−.150	.123	.137	−.244
X14	.342	.197	−.138	−.183	−.020	−.064
X15	.228	.085	−.106	−.023	−.054	−.087
X16	.123	−.044	−.155	.272	.086	−.130
X17	.128	.006	.079	−.136	−.103	−.048

4.2 Denominate the Common Factor

According to the factor loading matrix, try to denominate and explain the six factors.

Common factor 1: lack of skilled constructors, inappropriate construction technology, inappropriate construction scheme, lack of quality assurance system, construction errors, incapable supervisor, named as improper choice or decision.

Common factor 2: the financial difficulty, inappropriate monitor, improper design, named as the owner' responsibility.

Common factor 3: improper use of equipment and materials, lack correcting capability, clarification or answer questions not timely, named as the problem of equipment, material and rectification.

Common factor 4: imperfect procurement contract, change and claim, named as contract alteration.

Common factor 5: imperfect drawings or data, imperfect progress schedule, named as improper blueprint and schedule.

Common factor 6: inappropriate budget

4.3 Evaluate Factor Score

According to the above variables, six public factors' scores of the sample can be calculated. There are different methods to estimate factor's score. This paper uses the regression method of SPPS18 and gets the factor score's matrix, the results are shown in Table 4.

According to factor's score matrix, each common factor's score can be calculated, calculation functions are as follows.

$$\mathrm{F1} = 0.000X1 - 0.221X2 + \cdots + 0.128X17 \tag{1}$$

$$\mathrm{F2} = 0.423X1 - 0.295X2 + \cdots + 0.006X17 \tag{2}$$

$$\mathrm{F6} = -0.058X1 + 0.335X2 + \cdots - 0.048X17 \tag{3}$$

In different real estate project, each risk factor has different importance degree, as a result scores varies respectively according to the degree of performance. The function is used to calculate each public factor's value. The score reflects the factor's effect size, which is an important reference to take corresponding measures.

According to Table 2, structure principal component comprehensive model by using main factor variance contribution rate after rotation as the weight of every factor, in consequence risk values of the real estate during the construction stage appear. The function is as following [14].

$$\mathrm{Z} = 0.288F1 + 0.162F2 + 0.154F3 + 0.144F4 + 0.1437F5 + 0.107F6 \tag{4}$$

Put the value of $F1$, $F2 \ldots F6$ in the function, the whole construction risk value can be got. For different estate projects, this formula can scores its risk value, then the corresponding risk management measures can be taken to ensure successful completion of the project.

5 Conclusions

This article investigates and analyzes risk factors of the real estate project during the construction stage, using the method of factor analysis and getting the following conclusions:

Summarize 17 risk factors during construction stage of real estate project.

Derive six common factors from the 17 risk factors. According to the six factor's score, we can find out the main risk factors and take targeted measures.

According to each factor's score and the risk calculation function, a project's risk value can be calculated, which can provides basis for risk evaluation and management, and is important to improve risk management level and ensure construction quality.

Because the number of valid questionnaires retrieved is not enough and the coverage of respondents is relatively narrow, the common factors may not reflect all of the actual situations sufficiently. Consequently, expanding the scope of the survey and investigation object, then doing further research is necessary.

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Risk Assessment of Financial Lease for Medical Equipment Based on Neutral Network

Xing Bi, Wei-feng Yin, and Xin Dong

Abstract According to relevant principle, the article builds the risk assessment-indicator system of financial lease for medical equipment, and give weight to the index with help of professors, differentiate varies of risk level with boundary value. Furthermore, the article constructs BP neutral network model to evaluate the risk of financial lease for medical equipment, and testifies the model with data acquired from enterprises in industry of financial lease for medical equipment.

Keywords Medical equipment • Neutral network • Risk evaluation

1 Introduction

With the deep-going transformation of medical system and the construction of community hospital in China, hospital marketization will be an irreversible trend. The medical market that was under closed and monopolized before tends to be opened, which, therefore, intensify the competition among hospitals. To enhance the Comprehensive competitiveness rapidly, the hospital are supposed to improve the medical equipment.

Requirements for fast development of hospitals inevitably lead to some financial problems, and lease of medical equipment become a good choice after appropriation and loan in consideration of its flexible and convenient as a particular way [1]. Financial lease for medical equipment has numerous advantages, such as to alleviate the deficit of distribution of regional resources, improve the Matthew Effect in source distribution and assist medical institution in financial problems [2].

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Nevertheless, there exit predictable and unpredictable risk in financial lease for medical equipment, which requires leaseholder to be good at analyzing the cause and law of risk and furthermore, founding the effective mechanisms for risk management [3]. Therefore, it is beneficial to the whole medical system and financial system to strengthen the research especially quantitative research of risk assessment of financial lease for medical equipment [4].

The article is trying to study the strategy of risk assessment of financial lease for medical equipment with neutral network from the perspective of leaseholder.

2 The Construction of Assessment Indicator

2.1 Principle of Indicator Choosing

The risk assessment of financial lease for medical equipment can be studied in multi-layer and multi-angle, based on which the indicators could be divided into qualitative indicator, quantitative indicator, static indicator, dynamic indicator, total quantity indicator and structure indicator. Following are several principles for choosing indicators in this article:

1. Scientific. The choice of indicators and data, as well as calculation, should be on the basis of well-accepted scientific theory.
2. Operational [4]. The set of indicator system should not be too complex. Besides, the quantization of indicators and reliable of data must be taken into consideration.
3. Predictable. The set of indicator system is required to unearth and embody the risk underlying medical equipment-leasing companies.
4. Quantifiable. The assessment should be mainly based on quantitative research, combined with knowledge and experience of experts, qualitative analysis and quantitative analysis.

2.2 Construction of Indicator System

On the basis of principles above, as well as the research achievement of risk management of financial lease finished by foreign and domestic scholars and the practice of medical equipment-leasing companies [5], the article constructs an indicator system of risk assessment for financial lease of medical equipment including 3 first level indicators and 14 s level indicators, as what is showed in Table 1.

Table 1 Assessment indicators

First level indicator	Second level indicator	Assessment content (weights)	Assessment standard	Remark
Risk of financial lease for medical equipment	Credit risk	Stagnant rental ratio (0.3)	The weighted average value	
		Bad rental rate (0.3)		
		Overdue rental ratio (0.2)		
		Single customer concentration (0.2)		
	Market risk	Interest rate sensitivity coefficient (0.6)		
		Accumulative open foreign exchange positions ratio (0.4)		
	Liquidity risk	Liquidity loans ratio (0.3)		
		Liquidity gap rate (0.4)		
		Liquidity ratio (0.3)		Subtracted by 1 when calculation
	Operational risk	Monthly training hours (0.1)	Five levels: highest(1); high(0.7); normal(0.5); low(0.3); lowest(0.1)	
		Monthly lost customers (0.2)		
		Monthly complaints (0.2)		
		Monthly exiting persons (0.3)		
		Monthly informational system attacks by hackers (0.2)		

2.2.1 Indicators of Credit Risk

Credit risk is the risk of loss suffered by leasing companies as a result of counter party's failure to carry out the obligation [6]. Indicators of credit risk mainly include stagnant rental ratio, bad rental rate, overdue rental ratio and single customer concentration.

Stagnant rental ratio = (stagnant rent + stagnant loan)/(receivable lease payment + liquidity loan)*100 %
Bad rental rate = (bad lease + bad loan)/(receivable lease payment + liquidity loan)*100 %
Overdue rental ratio = (overdue lease + overdue loan)/(receivable lease payment + liquidity loan)*100 %
Single customer concentration = leasing volume of biggest customer/net capital*100 %

2.2.2 Indicators of Market Risk

Market risk is uncertainty of financial lease income price which mainly includes the change of interest rate and exchange rate [7]. The article adopts the interest rate sensitivity coefficient and accumulative open foreign exchange positions ratio to reflect the interest risk and exchange risk faced by medical equipment financial lease-companies.

Interest rate sensitivity coefficient = interest rate sensitivity assets/Interest rate sensitive liabilities
Accumulative open foreign exchange positions ratio = accumulative open foreign exchange positions/net capital

2.2.3 Indicators of Liquidity Risk

Liquidity risk includes two sides: liquidity of trading position and possibility to acquire enough money [8]. The article chooses three indicators to evaluate the liquidity risk including liquidity loans ratio, liquidity gap rate and liquidity ratio.

Liquidity loans ratio = liquidity loans/lease contract amount
Liquidity gap rate = liquidity gap in 90 days/liquidity assets in 90 days
Liquidity ratio = liquidity asset/liquidity loan

2.2.4 Indicators of Operational Risk

Operational risk is the risk of loss caused by problematic internal program, stuff or external event. The article adopts 5 indicators to reflect the operational risk including monthly training hours, monthly lost customers, monthly complaints, monthly exiting persons and monthly informational system attacks by hackers [9].

3 Assessment Model of BP Neutral Network

3.1 Concept and Structure of BP Neutral Network

Methods of risk assessments usually used are expert evaluating method, Fuzzy mathematics method, analytic hierarchy process and so forth, but the common disadvantage these methods share is the inaccurate of decision due to subjective factor in the assessment process [10]. To solve this problem, the article puts forward applying BP neutral network into the risk assessment of financial lease for medical equipment and construct the BP neutral network model.

ANN, a kind of dynamic study system [11], is a nonlinear simulation system that simulates the way brain deal with information. There are scores of methods of ANN [12], among which BP neural network of multilayer feed forward based on Error back propagation principle is most commonly applied (account for about 80–90 %). The BP neural network of multilayer feed forward is constituted by one input layer, one output layer and numerous hidden layers. The network structure Fig. 1 shows is classic BP neural network of 3-layer feed forward [13].

Linming Zhao and some others maintain that the number of training samples should be more than connection weights of neutral network [14]. Otherwise, generalization ability of network after training cannot be guaranteed. According to Cong Dong [15], the number of training samples should be more than that of hidden nodes. Or else, systematic error of neutral network has no relation with structure and feature of sample data and tends to be zero. The neutral network model like this would lack generalization mechanism. Accordingly, generating enough samples satisfying the standard according to assessment criterion is the key of the problem.

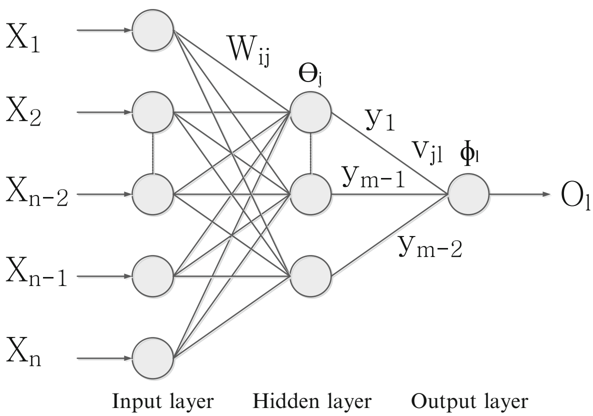

Fig. 1 Classic BP neural network of 3-layer feed forward

Table 2 Risk degree of financial lease for medical equipment

Comprehensive evaluation value	$0 \le S < 0.2$	$0.2 \le S < 0.4$	$0.4 \le S < 0.6$	$0.6 \le S < 0.8$	$0.8 \le S \le 1$
Risk degree	Lowest	Low	Normal	High	Highest

3.2 Confirmation of Hidden Layer Nodes J

At present, there is no theoretic guidance for hidden layer nodes, but we can adopt several empirical formulas as follows: $j = n + m + a$; $j = \log 2n$; $j = nm$. In the formula, m represents the number of output nodes, n represents the number of input nodes, a represents a constant between 1 and 10 [16]. In consideration of the forgoing formulas, we set the number of hidden layer nodes as $j = 4$.

3.3 Confirmation of Output Layer Nodes T

The output of network has only one indicator, that is the comprehensive evaluation value of financial lease risk for medical equipment, and $t = 1$. S represents the comprehensive evaluation value, and according to the properties of transfer function, $S\varepsilon$ [0, 1]. The comment is {lowest, low, normal, high, highest}, corresponding scale is as what is showed in Table 2.

3.4 Calculation Program of Neutral Network

Software of neutral network tool 1.0 is adopted. The software is multifunctional and convenient to use. Initial value of connection weights can be changed easily. And the connection weights group that has minimum error can be found through several times of trainings.

4 Results

The article chooses data from eight financial lease companies of medical equipment, among which data of seven companies is taken for sample training and data of one company is taken for test. Input all the data into software, after 50,000 times of sample trainings, we get the calculation result and relative error as is showed in Table 3.

Table 3 Calculation result and relative error

C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	Anticipation	Result	Related error
0.13	0.16	0.45	0.32	0.04	0.15	0.36	0.33	0.52	0.3	0.1	0.3	0.1	0.1	0.22	0.25	0.13
0.17	0.2	0.23	0.26	0.06	0.11	0.42	0.26	0.48	0.5	0.1	0.1	0.1	0.1	0.20	0.22	0.09
0.09	0.23	0.28	0.36	0.08	0.06	0.32	0.05	0.39	0.3	0.3	0.1	0.1	0.1	0.17	0.19	0.10
0.11	0.19	0.21	0.21	0.11	0.17	0.28	0.08	0.46	0.1	0.1	0.3	0.1	0.1	0.17	0.19	0.08
0.14	0.14	0.38	0.26	0.03	0.09	0.38	0.14	0.5	0.3	0.3	0.1	0.3	0.1	0.20	0.23	0.14
0.07	0.17	0.19	0.31	0.04	0.07	0.19	0.01	0.39	0.5	0.1	0.3	0.1	0.1	0.15	0.16	0.09
0.18	0.2	0.27	0.34	0.05	0.11	0.16	0	0.34	0.3	0.3	0.1	0.1	0.1	0.15	0.17	0.09
0.13	0.12	0.23	0.22	0.07	0.13	0.3	0.05	0.38	0.3	0.1	0.1	0.3	0.1	0.16	0.18	0.08
0.15	0.21	0.38	0.27	0.06	0.14	0.32	0.09	0.43	0.3	0.1	0.3	0.1	0.1	0.19	0.18	−0.05

We can infer from the test result of 8th set of data that the relative error between anticipated result and actual result is 0.05 %, which is small enough to verify the feasibility of BP neutral network model' s application in risk assessment of financial lease for medical equipment.

5 Conclusion

1. By analyzing the feature of financial lease risk, referring to foreign and domestic research results and combining the feature of medical equipment industry, the article constructs a set of assessment indicators of financial lease for medical equipment for aim of simple, scientific and accurate. The indicator system stressing the qualitative assessment is constituted by quantitative and qualitative indicators. Meanwhile, the article offers corresponding standards, and the weights of assessment indicators should be adjusted for different appraise subjective.
2. On the basis of indicator system above, the article constructs the BP neutral network model of risk assessment of financial lease for medical equipment, which offers a set of accurate, scientific and fast method for governments and financial lease companies. Of course, founding high accurate model needs some representative companies, so related department is expected to collect accurate data of companies and invite experienced experts to evaluate all the indicators so that abundant data base can be found.

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The Feasibility of Amended Creditmetrics Model's Application of Commercial Bank in China

Xing Bi and Feng Xue

Abstract The quantization of credit risk is always an important theme in Chinese financial sector. With the growth of Chinese economy, commercial banks increasingly need modern quantitative methods to manage credit risk. Creditmetrics model is a kind of quantitative methods which is very popular in developed countries. Though the credit rating system in our country is immature and the bonds market lacks mobility, but Chinese commercial banks need scientific quantitative methods to go with the developing of economy. While the amended Creditmetrics model provides a way for Chinese commercial bank to manage credit risk, so the study of application of amended Creditmetrics model in China is of practical significance.

Keywords Amended Creditmetrics model • Credit risk • Chinese commercial bank • VaR

1 Introduction

With the growth of Chinese economy and economic system, the role of financial system in economy development is more and more significant. While the commercial bank play an important part in Chinese financial system, what methods the commercial bank use to manage credit risk is a topic of great importance [1].

Chinese commercial banks have been using traditional methods to manage credit risk, for example, 5C method, credit score method and so on. The operation of these methods is simple but these means are subjective and are kinds of qualitative methods. The new Basel agreement proposes the quantization of credit risk which

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is the mainstream practice of the international lively bank. Under the background of economy globalization, Chinese commercial banks must follow this trend and develop suited quantitative methods [2].

2 The Theory Analysis of Creditmetrics Model

Creditmetrics model, which is developed by JP Morgan and some other financial institutions, is a kind of quantitative method to measure credit risk [3]. This method uses the VaR conception which means under a certain confidence level, a financial asset's possible maximum loss in a certain period of time in the future. It can calculate the loan portfolio's possible maximum loss under a certain confidence level in a certain period of time. Commercial banks using this model to manage credit risk can greatly raise the standard of credit risk managing. The Creditmetrics model's principle is as follows [4].

2.1 Circumstances of Single Loan

1. Fix the credit risk evaluation index system. The common system used in developed countries is established by Moody's or Standard & Poor's and so on. Basel Agreement proposes the application of internal rating method which rates on the basis of bank's internal data [5].
2. Establishing the grade transition probabilities matrix and the default recovery ratio matrix according to history data.
3. Calculate the probability of an asset's changing from one grade to other grade and the loss ratio of this asset in later grade. Then we can count the asset's present value. The ratio used in the calculating of the asset's present value is actually equal to 1-year forward zero coupon's interest rate in debenture of corresponding grade.
4. Calculate the present value of loan in different grades and the expected value's deviation distribution [6].

2.2 Circumstances of Loan Portfolio

The analysis of the loan portfolio must consider the interdependency of different loans. We can use the Monte Carlo method to calculate the risk of the loan portfolio. The steps of Monte Carlo method are as follows.

(1) Produce the critical value of loan repay in different grade.
(2) Estimate all interdependency of different loans.

(3) Count the asset repay model by joint normal distribution. The way to create correlated normal variable is Chocesky method. Every circumstance is formulated by n standard asset repay.
(4) For each circumstance, standardize the critical value of loan repay in step (1). Then integrate them in corresponding grade.
(5) Estimate the value of loan portfolio again according to the given yield curve.
(6) Repeat the above steps and draw the value portfolio distribution curve.
(7) Derive the future value's distribution percentage. Then calculate the VAR of the portfolio [7].

3 Amendment of Creditmetrics Model Based on Chinese Actual Situation

In China, the credit rating system is immature and the bonds market lacks mobility. We don't have perfect rating system and data bank like America. But Chinese commercial banks need scientific quantitative methods to go with the developing of economy and the Creditmetrics model has great potentiality to be used in our country. Here we amend the Creditmetrics model to make it suit to Chinese practice [8].

We assume a domestic commercial bank want to calculate the credit risk of all its loans which provide to enterprises by Creditmetrics model.

3.1 The Amendment of the Grade Transition Probabilities Matrix and the Calculating of the Default Recovery Ratio Matrix

Chinese commercial bank use five-level classification system commonly. Many banks have their own internal rating system. So we establish the grade transition probabilities matrix under the principle of five-level classification system based on this bank's history data. While the transition probability is calculated from past 5 years' data's weighted averages [9].

Considering Chinese practice, it's difficult to count the default recovery ratio of different loans in the market. But the bank can calculate it by actual data of past 5 years [10].

3.2 Estimate of Bond Value

As mentioned before, the ratio used in the calculating of the asset's present value is actually equal to debenture's 1-year forward zero coupon interest rate in corresponding grade. The overseas banks usually use maturity yield of bond of corresponding grade in the bond market. But Chinese bond market developed relatively late and only a little part of corporate bond trade in the secondary market. So we don't have available maturity yield. While we consider the loans as the bonds the bank bought and we use the spot rate theory and the forward rate theory of fixed income securities theory to calculate the 1-year forward yield rate based on the history data [11].

1. Calculate the theory spot rate by Bootstrapping method.

   We suppose the maturity yield of 1 year, 2 year, ..., n year's coupon bond are X_1, X_2, ..., X_n and the 1 year theoretical spot rate are Y_1, Y_2, ..., Y_n. We derive Y_n from X_n by the Bootstrapping method.

   We suppose this bank has a 1 year loan with a value of 100. It's equivalent of a par issue bond. We use C to represent coupon and use F to represent maturity value and F = 100. Then the bond is equivalent of a 1 year zeroes whose maturity value is (C + F). Then we have formula as follows [12].

$$100 = (C + F)/(1 + Y_1) = (C + F)/(1 + X_1) \tag{1}$$

   Among the above formula, $C = F^*Y_1$.

   Likewise, if this bank has a 2-year loan with a value of 100, it is equivalent of two par issues. One is a 1 year zeroes whose maturity value is C and the other is a 2 year zeros whose maturity value is (C + F). We have formula as follows.

$$\begin{aligned} 100 &= C/(1 + X_2) + (C + F)/(1 + X_2)^2 \\ &= C/(1 + Y_1) + (C + F)/(1 + Y_2)^2 \end{aligned} \tag{2}$$

   Among the above formula, $C = F^*Y_2$.

   Then we can conclude the common formula as follows.

$$\begin{aligned} 100 &= C/(1 + X_i) + C/(1 + X_i)^2 + \cdots + (C + F)/(1 + X_i)^{\mathrm{i}} \\ &= C/(1 + Y_1) + \mathrm{C}/(1 + Y_2)^2 + \cdots + (C + F)/(1 + Y_i)^{\mathrm{i}} \end{aligned} \tag{3}$$

   Y_i (i = 1, 2, ..., n), $C = F^*Y_i$.

2. Calculate the yield of forward zeroes by the theoretical spot rate.

   Forward rate is a kind of yield covers a period from one time point in the future to another time point later. We use f_{mn} to stand the forward rate from the time point t_m to the time point t_{m+n}. We have derivation process as follows [13].

$$(1 + Y_{m+n})^{\mathrm{m+n}} = (1 + Y_m)^{\mathrm{m}*}(1 + f_{mn})^{\mathrm{n}}, \tag{4}$$

So we can conclude formula (5) as follows.

$$1 + f_{mn} = \left[(1 + Y_{m+n})^{\mathrm{m+n}}/(1 + Y_m)^{\mathrm{m}}\right]^{1/\mathrm{n}} \tag{5}$$

Because we want to know the 1 year zeroes' yield m years later, so in the Creditmetrics model, n = 1. So we have formula as follows.

$$1 + f_m = (1 + Y_{m+1})^{\mathrm{m+1}}/(1 + Y_m)^{\mathrm{m}} \tag{6}$$

We can count 1 year zeroes' yield i years later by this formula.

3. Calculate 1 year zeroes' yield 1 year later by the f_i. We use Z_i to stand this yield. The steps are as follows [14].

$$(1 + Z_1) = 1 + f_1 \tag{7}$$

$$(1 + Z_2) = [(1 + f_1)\,(1 + f_2)]^{1/2} \tag{8}$$

$$\ldots$$

$$(1 + Z_i) = [(1 + f_1)\,(1 + f_2)\ldots(1 + f_i)]^{1/\mathrm{i}} \tag{9}$$

Then we can calculate the value distribution of different grades' loans 1 year later by Z_i.

3.3 The Calculating of VaR

Under the Creditmetrics model, there are two ways to count VaR. One is based on the hypothesis of normal distribution which the loan value complies with. The other is based on the loan value's actual distribution. Because the loans of our countries granted exist serious fat tail phenomenon instead of comply with normal distribution, the later way is suitable to Chinese practice [15].

4 The Example of the Amended Creditmetrics Model's Application in Chinese Commercial Bank

We suppose there is a commercial bank in China who uses five-level classification method. The loans is classified into five grades by property quality and the five grades we use A, B, C, D, E to stand by. Among the five grades, E level has bad property quality and can't be repaid overdue. So the E level is equivalent to breaking the contract.

Table 1 The grade transition probability matrix

The grade end of the year	The grade next year (%)				
	A	B	C	D	E (default)
A	88	10	2	0	0
B	8	82	6	5	1
C	2	9	77	12	8
D	0	1	8	71	20

Table 2 Default repay ratio matrix

Credit rate	A	B	C	D
Default repay ratio (%)	50	40	30	20

Table 3 Maturity yield in different age limit (%)

Credit grade	1 year	2 year	3 year	4 year
A	2.1	2.5	3.2	4.0
B	2.8	3.3	3.8	4.4
C	3.4	3.9	4.6	5.2
D	3.9	4.4	5.0	5.5

Now this bank has a loan which is in B grade. This loan is worth 1 million yuan and its due time is 3 years. Its annual interest rate is 5 %. This bank will use amended Creditmetrics model to calculate this loan's 1 year credit risk.

4.1 The Grade Transition Probabilities Matrix and the Default Recovery Ratio Matrix

The bank analyses the enterprises' data of past 5 years who loan from it and take the arithmetic mean of different years' transition probabilities as the sum. Eventually the bank infers the grade transition probabilities matrix is shown in Table 1.

The bank takes the arithmetic mean of the data of past 5 years as the sum, and infers the default recovery ratio matrix which is shown in Table 2.

4.2 The Calculation of Loan's Present Value

This bank infers the maturity yield of loan if every grades in different age limit according to history data. The maturity yield is shown in Table 3.

In the light of formula (3), (6), (9), the bank calculates the 1 year forward yield of different grades' loans as is shown in Table 4.

Table 4 One year forward yield of different grades' loans (%)

Credit grade	1 year	2 year	3 year
A	2.9	3.8	4.36
B	3.8	4.3	5.0
C	4.4	5.2	5.85
D	4.9	5.6	6.16

Table 5 Value distribution corresponding to different grades

Credit grade	Probability(%)	Value after 1 year (million yuan)	Value deviation (%)
A	8	1.0688	1.08
B	82	1.0512	0.68
C	6	1.0284	2.96
D	5	1.0201	3.79
E	1	0.40	65.8

According to the table above, if this loan remains in B grade 1 year later, its present value after 1 year is:

$$\begin{aligned} V_B &= 5 + 5/(1 + 3.8\ \%) + 5/(1 + 4.3\ \%)\,2 + 105/(1 + 5\ \%)\,3 \\ &= 1.0512 \text{ million yuan} \end{aligned}$$

If the B-grade loan defaults 1 year later, it changes into E grade. According to the Table 2 its present value after 1 year is:

$$V_E = 0.4 \text{ million yuan}$$

Likewise the bank calculates the probability of this B-grade loan changing into other grades. The value distribution corresponding to different grades of this B-grade loan is shown in Table 5.

This B-grade loan's mean value end of the year is:

$$\begin{aligned} V &= 106.88^{*}8\ \% + 105.12^{*}82\ \% + 102.84^{*}6\ \% + 102.01^{*}4\ \% + 40^{*}2\ \% \\ &= 1.058 \text{ million yuan} \end{aligned}$$

4.3 The Calculation of VaR

According to Table 5 above, when the confidence level is 1 %, the VaR = 0.658 million yuan.

When the confidence level is 5 %, according to the VaR when the confidence level is 1 and 6 %, the bank use linear interpolation method to work out that when the confidence level is 5 %, the VaR = 0.1619 million yuan.

So after above steps the bank figure out this B-grade loan's credit risk 1 year later. When the bank wants to estimate the credit risk of loan portfolio, it can use the Monte Carlo method and follows the steps mentioned in Sect. 2.2.

5 Discussion About the Application of Creditmetrics Model in Chinese Commercial Bank

5.1 Significance of Creditmetrics Model for Chinese Commercial Bank

By means of above chapters of amended Creditmetrics model and the example analysis, we can see this model has the feasibility of applying in China commercial bank. Take Chinese practice into account, Creditmetrics model has great significance for the credit risk quantization of our countries' commercial bank which is listed as follows.

1. This model allows for the different grades of enterprises and the influence on credit risk when the grades changed.
2. This model concerns nearly all kinds of credits and takes the diversity of different trade. It's a typical method which can compare enterprises in different professions.
3. Creditmetrics model is a kind of typical method which carries out the VaR concept. In recent years, VaR concept develops rapidly in practice field depends on its scientific quality and practicability and is agreed by Basel committee. So in order to follow the world's pace, Chinese commercial bank must grasp the method of VaR [16].

5.2 The Favorable Conditions of Quantization of Credit Risk in Chinese Commercial Bank

5.2.1 Interior Condition Mature Progressively

Reformation is carried out in domestic commercial bank step by step and credit risk management is taken seriously gradually. Banks learn and absorb advanced international technique for the quantization of credit risk. While the credit rating system and the data base is being perfect day by day. Chinese financial academic community's study about the quantization of credit risk also provides a theory basis for the application of these methods.

5.2.2 Exterior Favorable Condition's Satisfied

On the one hand exchange of advanced calculation method of credit risk increases profited from China's joining in the WTO. On the other hand, tough international competition compels Chinese commercial bank continually learn western advanced technique and management experience [17].

6 Conclusion

We must know that the ground in our country of initiating quantization of credit risk is not thick. So for follow the pace of international economy, our country must respond to challenges positively and learn the advanced technology and reform the lagging pattern in economy development. We trust that the data of Chinese commercial bank market is being perfect and the level of management of banks improves continuously. So the study of amended Creditmetrics model for Chinese commercial bank's management of credit risk makes sense.

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Part VII
System Modeling and Simulation

System Dynamics Modeling in Coal Mine Safety

Xian-gong Li, Xue-feng Song, and Xin-chun Li

Abstract In order to study the occurrence mechanism of coal mine accidents in more detail, a simulation model on mine safety system was constructed by Vensim. In the simulation model, the human related, equipment related, environment related and cultural factors in the accidents causing process are analyzed to find the coal mine accident mechanism. With simulation in different scenarios and sensitivity analysis, the variation of causing factors and the influential relations are studied to seek the control approaches and management measures to the accidents of coal mine system.

Keywords Coal mine safety • Causing factors • System dynamics • System simulation

1 Introduction

China is a superpower of the world's coal production and consumption. People enjoying the benefits of the coal resources, but always cannot avoid the problem of safety in process of coal production. Safety is the premises of human survival and development. The country's harmonious development needs more safety in China today. The good news is that in the recent years, with the national attention and promotion, the enterprise main responsibility for the implementation of the increase in safety investment, the application of the scientific and technical equipment as well as raises the level of coal mine safety; mine safety situation in China achieves a sustained upturn. In 2011, the national coal mine accident deaths dropped below 2,000 and the production safety indicators are more obvious improved. However,

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compare to other major coal production country in the world, the death toll of all kinds of accidents in coal mines in China is still high. Therefore, to study the mechanism of coal mine accidents and accident prevention and control measures, to continue to reduce the accident rate of the coal mine have important significance.

The research of accident used to focus on the individual person or the casual event chain (Heinrich 1936). In event based models, the causal factors depend on the events that are considered and the selection of the conditions related to those events. The casual event chain seems accident as the event happened in a time line. Forward sequences (as in FMEA or Event Trees) or backward ones (as in Fault Trees) may be used in the accident cause analysis. As such, event based models encourage limited notions of causality—usually linear causality relationships are emphasized, and it is difficult to incorporate non-linear relationships, including feedback. In addition, some important causal factors are difficult to fit into simple event models. For example, studies have found that the most important factor in the occurrence of accidents is management commitment to safety and the basic safety culture in the organization or industry [1]. Recently, the systems approach is arguably the dominant concept within accident analysis research.

For instance, Cooke (2002) describes a system dynamics simulation of Westray mine disaster [2]. Leveson (2004) seemed system safety as the emergent character which arises by interaction elements in a system from complex system perspective and put forward the Systems Theoretic Accident Modeling and Processes model (STAMP). The cause of accident, instead of being understood in terms of a series of events, is viewed as the result of a lack of constraints imposed on the system design and on operations, that is by inadequate enforcement of constrains on behavior at each level of a socio-technical system. Accidents result from a lack of appropriate constraints on the interactions [3].

Reason considers that most accidents can be traced to one or more of four levels of failure: Organizational influences, unsafe supervision, preconditions for unsafe acts, and the unsafe acts themselves. In he’s Swiss Cheese model, an organization’s defenses against failure are modeled as a series of barriers, represented as slices of Swiss cheese. The holes in the cheese slices represent individual weaknesses in individual parts of the system, and are continually varying in size and position in all slices. The system as a whole produces failures when all of the holes in each of the slices momentarily align, permitting (in Reason’s words) “a trajectory of accident opportunity”, so that a hazard passes through all of the holes in all of the defenses, leading to a failure [4].

2 Materials and Methods

Coal mine production and safety are inseparable, but sometimes contradictory, such as in the allocation of the limited resources. A risky activity may be helped to mine production but not allowed for safety. In this paper we define the dominance of the production of safety to carry out the research. If the coal mine safety work more seriously, we believe that the production advantage of the safety to be small, otherwise great. In fact, the production of the safety of the size of the dominance by some of the indicators in the coal mine in the organization reflected the size of the powers of the members of the organization such as coal mining safety, safety management agency status (such as safety management committee).

The behavior of the coal mine managers and miners is a direct impact on the performance of coal mine safety. Human behavior is dominated by its psychological. In this article, we define a personal commitment to safety management, refers to a person willing to make in order to achieve the coal mine safety and the extent of the efforts made. Similarly, the definition of the organization's safety management commitment means the coal mine organization willing to make in order to achieve coal mine safety and will make efforts to the extent of coal mine safety management commitment, which mainly through the system of the coal mine management command.

Mine safety system is the core of this study subsystem, main soft factors including staff, machinery, equipment and materials, environmental production elements and system specifications. Safety management of coal mining enterprises in the coal mine safety subsystem, the level of commitment by the impact of the rate of change of the safety management commitment, while the feedback effects influence the rate of change of the safety management commitment. Safety management commitment to the rate of change is also influenced by the goal of change management commitment and safety management. Commitment to the goal of safety management is decided by the organization's largest management commitment and pressure to change the safety commitments the pressure to change the safety commitments from the effects of relative accident rates on the safety management commitment, and the impact of the accident [1].

The personal safety commitments by the impact of the rate of change of personal safety commitments in turn will affect the rate of change of personal safety commitment. The rate of change of personal safety commitments personal safety objectives and a commitment to change the personal safety needs time to decide. Personal safety commitment affects the unsafe behavior and was affected by the management layer's safety pressure. The accident rate level of the system is determined by the accident rate of change and average accident time. At the same time, the accident rate by unsafe acts and unsafe machinery and equipment status and unsafe environmental conditions [2].

We can tell from above analysis, a major coal mine accidents such as gas accidents are always come from three conditions that the gas concentration, the presence of plenty of oxygen and high-temperature fire source [3]. In our model, taking into account these factors causing the formation of similar characteristics and reasons for the convenience of the model, based on the characteristics of these cause factors, which were divided into two categories; one category is Unsafe Behavior another class the unsafe condition of the machine and the environment. Average accident rate is considered as the system output, representing the system's level of risk for major gas accidents, coal mine industry accident rate as the reference value of the mine accident rate, as shown in Fig. 1. That the accident rate of unsafe behaviors, unsafe state and industry accident rate function [4].

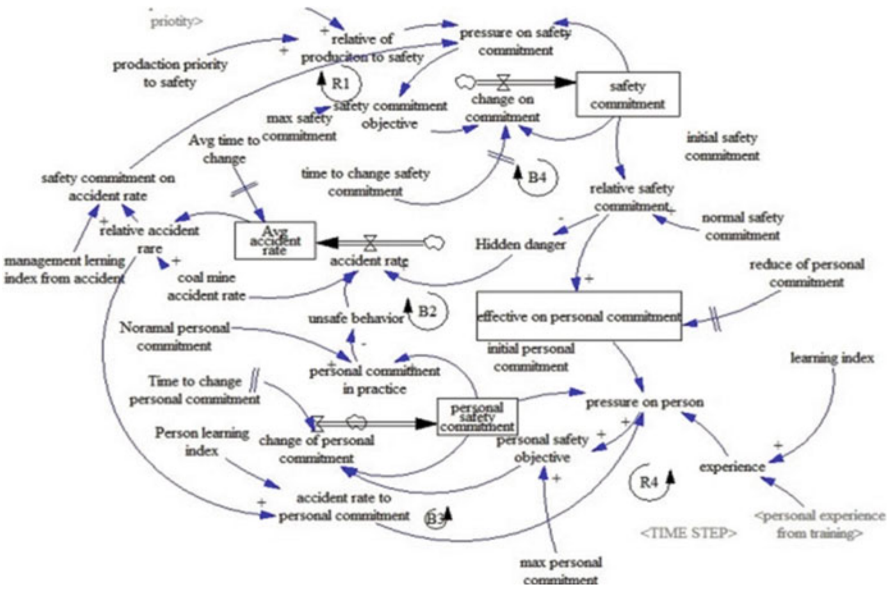

Fig. 1 Safety subsystem of coal mine

2.1 Hypotheses

1. The system boundary of this study is a coal mine system. The research model follows an accident common causes assumptions in the study [5].
2. This paper simulation study assuming mine production is basically stable in the simulation cycle, coal mine production safety management is not disturbance by external factors, such as national coal production safety control policies change, the coal mine managers in the position according to its own system and receive information and feedback to make behavioral responses [6].
3. In the organization of coal production, coal miners, and the organization has a generally safe management commitment and maximum safety management commitments were assumed to be 80 % (normal level) and 120 % (the highest level) [2].

2.2 System Dynamic Model

According to the causal relationship between the key factors and variables and constant auxiliary variables, based on the analysis of mine safety accidents path, the coal mine safety system was established in accordance with the system dynamics modeling approach. The feedback loop flow diagram is shown in Fig. 1. The stock of the level of commitment of the safety management of coal mining enterprises in the system dynamics model, the feedback loop is increased with the rate of change of a rate variable safety management commitment. Reduce the rate of change due to the change of commitment to safety management and safety management objectives and safety management commitment. Commitment to the goal of safety management is decided by the organization's largest management commitment and pressure to change the safety commitments increase. The rate of change promised by the personal safety of mine workers safety management commitment and personal experience factors. The model gas explosion mechanism is based on the mechanism of actual gas accident in a relatively simple way to modeling [7].

There are three main feedback loops in the model:

R1: Commitment to safety management commitment to safety management pressure $+ \rightarrow$ safety goals $+ \rightarrow$ Safety Management $+ \rightarrow$ change promised change $+ \rightarrow$ Safety Management commitment$+$.

R2: Average accident rate $+ \rightarrow$ relative accident rate $+ \rightarrow$ relative accident rate effect of personal commitment $+ \rightarrow$ change personal safety commitments pressure $+ \rightarrow$ personal safety goals $+ \rightarrow$ personal safety commitments change $+ \rightarrow$ personal safety commitments $+ \rightarrow$ unsafe behavior $- \rightarrow - \rightarrow$ average accident rate $-$ accident rate changes.

R3: The changes promised by the pressure of the average accident rate $+ \rightarrow$ relative accident rate $+ \rightarrow$ relative accident rate on the effect of management commitment $+ \rightarrow$ change safety commitments $+ \rightarrow$ safety management objectives $+ \rightarrow$ Safety Management $+ \rightarrow$ safety management commitment $+ \rightarrow$ relative safety management commitment $+ \rightarrow$ state of unsafe $- \rightarrow$ accident rate changes $- \rightarrow$ average accident rate$-$.

Figure 1 shows coal mine safety management subsystem feedback flow diagram. Sterman pointed out that looking for the key feedback loop of the system more than explore the complex definition of unnecessary meaningful. As can be seen from the figure, this model contains feedback loops related to organizational safety management commitment, personal safety management commitment, employee behavior, the accident rate and so on.

Follow the steps and methods of system dynamics simulation, set the respective rate variable, dynamic equation between level variables and auxiliary variables. The data were inputted to the simulation model of the from a coal mine. The simulation cycle setting model for 148 weeks (about 3 years) and the simulation step for 4 weeks, debugging repeatedly model, finally get the simulation results of initial model.

3 Results

The use of feedback complexity of the system dynamics method of coal mining complex system, we first need to establish the evolution of a major accident causality and process flow diagram of the feedback system established as the main variable

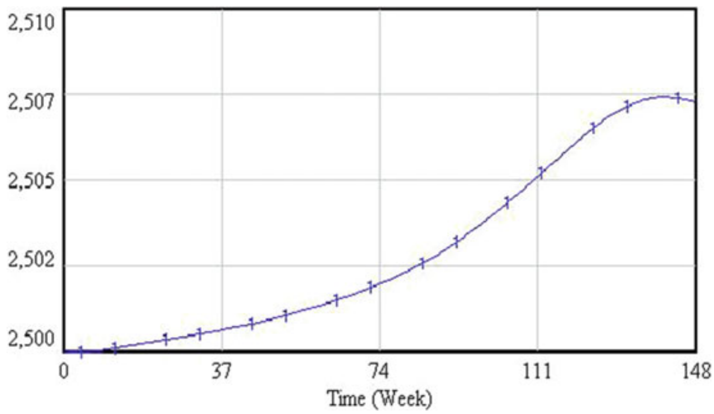

Fig. 2 Change of coal miner numbers

in a the stream bit with flow rate feedback loop analysis. Find out all or part of an important feedback loop in the flow graph structure model built by the flow rate into the basic tree embedded into the structure of the model, and then identify the fundamental mode and dominant feedback loop systems archetypes, led feedback loop parameter debug way to debug the system model, the feedback loop analysis, results analysis as well as the effect of the test.

The previous analysis in accordance with the system dynamics simulation steps 4 system dynamics flow diagram is created, setting various flow rate variables, the flow bit variables as well as the auxiliary variable between the equations. Coal mine safety system collected data is entered into the simulation model. Set the model simulation period of 148 weeks (about 3 years) as well as simulation step for 4 weeks, repeated run debug model, and finally get the simulation results of the initial model [8].

As can be seen from Fig. 2, due to the demand of coal mine production of human resources, will lead to coal mines to expedite the recruitment rate to hire more workers to meet production needs. Just like in recent years, the increasing demand of energy bring more profits to coal mine enterprises, which need to employ more labors. It can be seen from China Statistic Press 2012 that the labors amount is no more than 4.9 million in 2003, but has been 6.1 million in 2011. The new employees need much more safety and skill training and need to learn in the production practice.

As can be seen from Fig. 3, at the same time, the introduction of new employees to bring the experience of the average production of the entire coal miners decline, thereby affecting the level of coal mine safety. New employees into the coal mine to participate in the training, with the coal mines of pre-service training for new workers, as well as on-the-job training, the production experience level of the entire coal miners will gradually increase, and then bring the improvement of the overall safety situation in the coal mine.

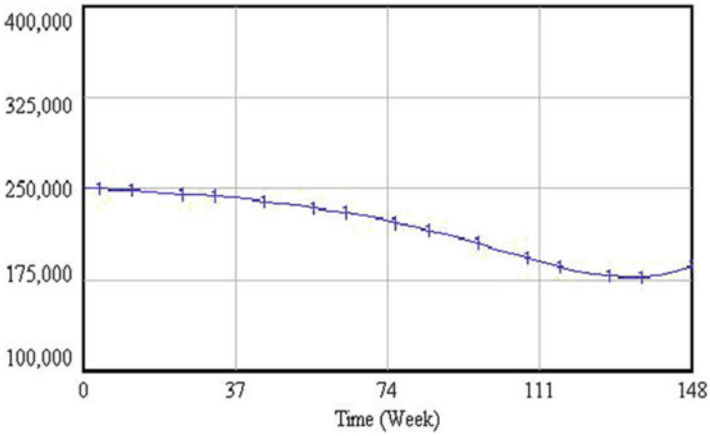

Fig. 3 Change of coal miners' experiences

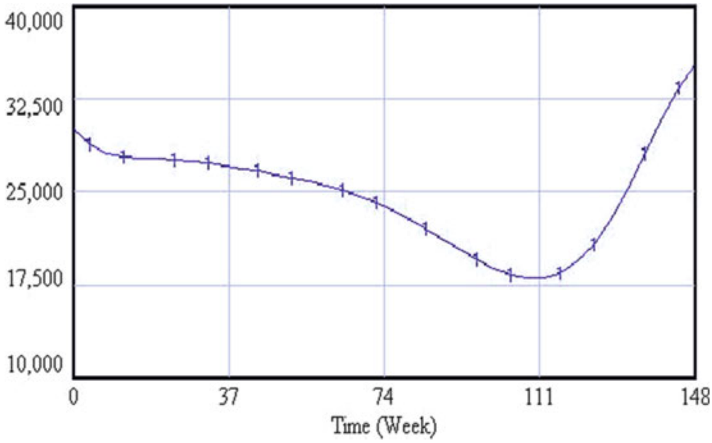

Fig. 4 Change of the coal mine production

Affected by mine accidents, the mine production changes in the simulation period is shown in Fig. 4. Part of the reason for the decline in coal production trends due to frequent accidents, losses caused by too much. The entire production of the coal mine in the simulation cycle is dynamic production target in order to achieve the target coal production, the progress of the production control around constantly adjust production targets, it also brings the impact on the system. Caused by coal mine safety system it becomes a dynamic system.

As shown in Fig. 5, it is coal mine additions affected by mine accident losses. As can be seen from the Fig. 5, with the conduct of the coal production, coal production gradually increased mine average accident rate rises at the same time, bring about the loss of coal production capacity, thereby also increasing coal production losses

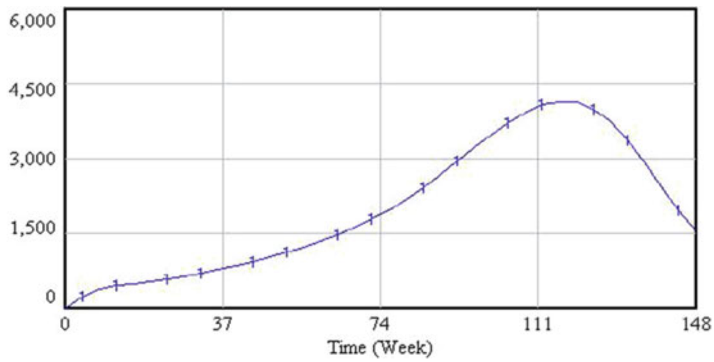

Fig. 5 Change of the coal mine additions

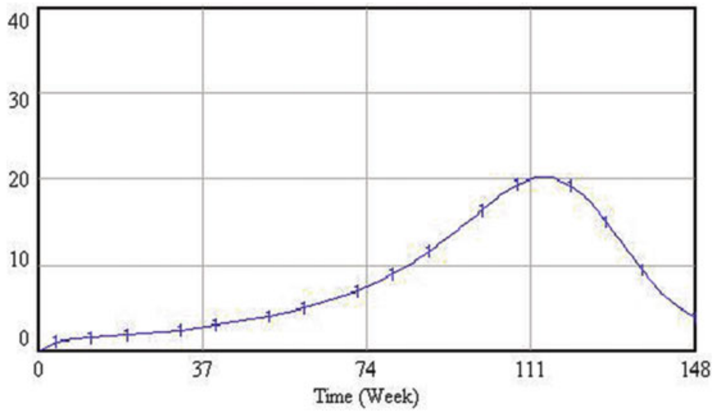

Fig. 6 Average accident rates

caused by the mine [9]. Therefore, it can reduce the average accident rate of the coal mine coal mine production can bring economic benefits increase for coal mine. Especially in the long term, this effect is more pronounced. From side to prove the coal mine safety and production is unified, improve coal mine safety production [10].

As shown in Fig. 6, in the simulation cycle, the average accident rate of the coal mine some time ago is gradually increased, this increase with the progress of coal mining, there will be more and more dangerous source, if the source of these dangerous effective management cannot be, or not existing management control unsafe behavior of employees, the rate of coal mine accidents will increase. According to the accident iceberg theory [11], many small accidents may be a sign of major accident. However, this trend of rising accident rate does not practice has been the development continues, this trend will increase the safety of managers to manage stress, and enable managers to take appropriate measures to strengthen the management, and ultimately the coal mine accident rate down [12].

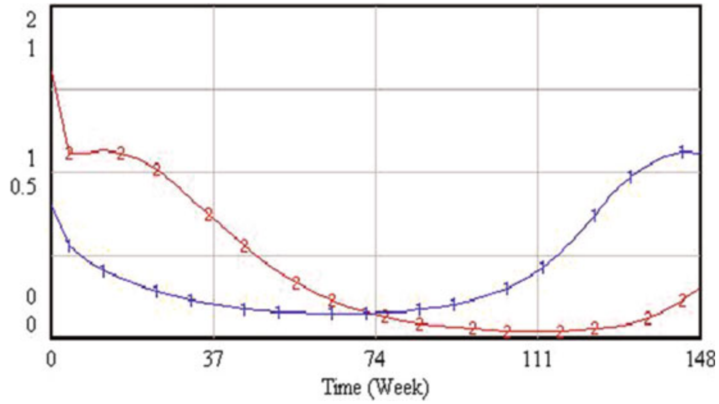

Fig. 7 Safety management commitment and personnel commitment

In addition, mine managers should be aware of the information flow delay in the coal mine safety system, delayed effects in the system to consider when making decisions. It can be seen from Fig. 7 that there is a noticeable delay effect between the organization's safety management commitment and personal safety management commitment [13]. In addition, personal safety management commitment is more variable than the organization's safety management commitment. Compare to organization's decision making, personal decision making come with a low cost [14]. As well as the organization and management commitment to small changes may bring large junior staff personal behavior change [15].

4 Discussion

Therefore, there are three aspects of this problem have to be addressed

1. The accident is the result of the output of the system. Due to the presence of many elements of the impact of coal mine safety, coal mine production, the accident is almost inevitable. The role of coal mine safety management is to control the factors leading to the accident, as much as possible to reduce the probability of accidents.
2. Dynamic changes in the safety management commitment to influence the behavior of employees and even coal system safety, the establishment of a safety management culture can help to improve the safety management commitment, and can play a role in the long term.
3. Coal mine safety should keep higher than the production advantages. For a small number of large state-owned mines for coal occurrence conditions good, the problem may not be very significant, but for the local coal mines, especially township coal mines chase for corporate profits, so this problem is particularly

prominent. In these mines, is not a “safety first” but “production first” or “efficiency first” safety conditions do not allow the case is still produced, which led to higher rate of coal mine accidents, and ultimately a major mine accidents.

5 Conclusion

From the results obtained up till now, it is concluded that the time delay and feedback effect should be considered in the coal mine safety decision making. The management commitment to safety should not be changed frequently and a consistent management commitment to safety is needed. The miners should be seen as the main body of coal mine safety. The average incident rate reflects the safety level of the system and highly correlated with the management commitment to safety. And the supervisors should pay more attention on it to prevent significant gas accidents. Supervisors can make a difference in achieving sustainable results in coal mine accident prevention by enhance the coal mine safety management level.

The suggestions on measures to reduce the coal mine accident risks can be given by reduce the average incident rate. The measures include close loop in time hidden danger management in order to manage the feedback and time delay in the safety system, creating credit management system and enhancing miners’ personnel commitment to safety in order to reduce miner’s unsafe behavior so as to reduce the average incident rate.

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Study on the factors for Innovation Capability of Equipment Manufacturing Industry Based on Structural Equation Model: Empirical Analysis of Guizhou Province

Shu-jun Chang, Ting Wang, Hong-liang Hu, and Yang Gao

Abstract To enhance the innovation capability of Chinese equipment manufacturing industry and to promote the development of enterprises in the "12th Five-Year" period, based on integration of literature analysis, theoretical studies, spot investigation and questionnaires, this article select five main influencing factors which impact the innovation capability of Chinese equipment manufacturing enterprise, as well as establish a model relating the influencing factors and innovation capability. The Guizhou province was taken as a case to study and the AMOS7.0 software was used to analysis our model. The results indicate that cooperation in research and market are two significant influencing factors that affect the innovation capability of Guizhou's equipment manufacturing enterprise. This study combines qualitative analysis with quantitative analysis, which improves the deficiencies of existing research and enhances the reliability of conclusion.

Keywords Equipment manufacturing industry • Innovation capability • Influencing factors • Structural equation modeling

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1 Introduction

Equipment manufacturing is a general name of the enterprise which produces technical equipment to maintain national economy and security, and is also a general name of manufacturing departments which equips various department of national economy with tools to make low-level reproduction and to expand reproduction [1]. "Equipment Manufacturing" hasn't been proposed in other countries yet, it is a Chinese characteristic noun put forward to distinguish it from the "General Manufacturing". It is a basic industry that should receive highly attention on our way to the fully industrialization and to develop to a bigger and stronger manufacturing country.

Nowadays, the equipment manufacturing becomes a strategic industry of China. As a series of policies have been issued, such as "portfolio of opinions for accelerating the revitalization of equipment manufacturing" and "plans for the restructuring and the revitalization of equipment manufacturing", provinces have established the plan for the development of the equipment manufacturing during "12th Five-Year" period, aiming to accelerate the development of Chinese equipment manufacturing industry and to elevate the level of autonomy of the major technical equipments as well as to strengthen the innovation capability of equipment manufacturing enterprises. This article give a bunch of advices to the equipment manufacturing based on empirical analysis of the leading factors impacting the innovation capability of equipment manufacturing enterprises.

2 Review

Researches on the influencing factors of innovation capability could be divided into two fields: qualitative study and quantitative study. Qualitative study is more common. The views of research are various. From the technical innovation perspective, Zhu analyzed the interaction of different influencing factors [2]. Xu and Zeng analyzed the innovation capability of equipment manufacturing in Chongqing based on the view of independent innovation [3]. Standing on the point of improving the ability of collaborative innovation, Liu and Chen built a collaborative system correlating the producer service industry and manufacturing [4].

The quantitative study discloses deficiencies compared with the qualitative study, which is caused by the difficulty to establish evaluation indicators and to select optimal analytical method and data. Learning from historical literatures, we find that evaluation indicators is established mainly based on two aspects, including inputs and output. With the establishment of the indices of innovation based on outputs and inputs, Hollanders and Esser used the DEA method to analyze efficiency between input and output, and then evaluated the innovation capacity of various countries and their position in the world [5]. On the basis of the distinction of firm size, Fan and Liu used panel data to estimate the function of various factors affecting the technological innovation of Chinese high-tech industry [6].

We find out that qualitative research involves a broad field, but it lacks certain empirical results to support the conclusion. Quantitative research to some extent ensures the practicality of the conclusions, but the empirical analysis also needs to more attempts due to the limitations of the analytical methods. Integrating the qualitative and quantitative analysis, lessons from the inadequacies of the existing research are learned in this article, providing a new direction for the research on influencing factors.

3 Analysis

3.1 Determination of Factors

Analysis of influencing factors is very important. To better reflect the real situation of the equipment manufacturing industry, we determine five main influencing factors that affect the innovation capability of equipment manufacturing enterprises in Guizhou province, on the basis of theoretical analysis, investigation into the companies as well as communicating with the technicians and manager. The factors are the corporate culture, market, innovators, employees' satisfaction and cooperation in research.

The corporate culture is enterprises' invisible soul and cohesive spine. It is the internal driving force, which can direct employees to the goal of enterprise. Since products are market-oriented, it is the external driving force of the market that will create endless power for companies to be innovative. As the main role of innovation, people play the most vital roles in innovation. So the innovators have to become a factor we must concern about. The famous American psychologist Maslow's theory, the hierarchy of needs, tells us that only meet the current demand can people devote themselves to the work. Employees' satisfaction is the requisite to maintain the enterprises' innovation capacity. In the current market environment, when an enterprise plan to undertake independent innovation, no matter in the financial section, human resources section or material resources section, the investment is huge, this would dampen the profit maximization. Therefore, as to most enterprises, cooperation in research which is an approach for enterprises to share resources with other enterprises, it could be quite beneficial for enterprises to cut down costs. The five factors are favorable representative, containing internal and external aspects.

3.2 Hypothesis

Li, Fan, and Zhao found out that supportive culture and innovative culture are conducive to independent innovation of enterprises [7]. Sun proposed that excellent corporate culture would provide incentives and support for technology innovation [8]. A hardware platform can be destroyed, but as long as there exists a kind of excellent corporate culture in harmony with employees' values, it will provide a steady stream of inner motivation for enterprises to improve the innovation capability. It can be seen that the corporate culture plays a positive role in improvement of innovation capability and encouragement of innovators.

H1: Corporate culture has an effect on innovation capability.
H2: Corporate culture has an effect on innovators.

Han and Wu proposed that Chinese enterprises lack of scientific evaluation systems of selection of innovative products, let alone an enormous market research institution to communicate with the customer [9]. The products not only have low added value, but often disjoined with the market, which results in innovation failure. Market is the driving force to pull enterprise innovation. The more market demand, the stronger enthusiasm would be invested in innovation. Chinese equipment manufacturing enterprises invest most capital into the scientific research, development of new technologies and purchase advanced equipment. The money invested in market research is quite small, which may explain why R&D achievement disjoins with the market and affects the ability to innovate.

H3: Market has an effect on innovation capability.

Many scholars believe that investment into human resources could have a significant impact on innovation, especially the scientific and technological innovators, which would be the basis of scientific and technological innovation. In many enterprises, however, most of the engineers and technicians are busy with the daily production, technical work, as well as the study on traditional disciplines. Only few of them participate in the high-tech development and research in applied disciplines. Therefore, the lack of innovators dampens the capacity of Chinese equipment manufacturing enterprises to promote innovation.

H4: Innovators has an effect on innovation capability.

Chen pointed out that the support from employees for innovation would have a significant impact on technology innovation of enterprise [10]. Employees' positive attitude to innovation is the important guarantee for successful innovation. The effect of investment of innovators on innovation shows not only in the aspect of the amount of the person but also in the aspect of the quality of the person. Learning from the theory of Maslow's hierarchy of needs, if we want to attract talents and to inspire their enthusiasm in innovation, the first step is to meet their demands, which is so-called employees' satisfaction. Only under the circumstance that one's current demands are satisfied can people concentrate on scientific research to improve the efficiency of innovation.

H5: Employees' satisfaction has an effect on innovator.
H6: Employees' satisfaction has an effect on innovation capability.

Han also indicated the factors which affect the novelty of the innovative products are the degree of cooperation between enterprise, the attention on the forefront of world science and technology, foundation and development capabilities of

Table 1 Evaluation indicators of factors

Factors	Evaluation indicators
Corporate culture	Innovation culture concepts (C1) Holding lectures (C2) Rational incentive system (C3) Research achievement discussion (C4)
Market	Market investigation of new products (M1) Products to meet market trends (M2) Meeting customer requirements (M3) Threat of substitutes (M4)
Innovators	Sufficient innovators (I1) Research ability of innovators (I2) Communications between innovators (I3) Innovators' support for innovation (I4) Innovators' participate in innovation (I5)
Employees' satisfaction	Satisfaction of salary and welfare (S1) Satisfaction of space for the promotion and development (S2) satisfaction of work environment (S3) Satisfaction of incentive system (S4) Realization of personal value (S5)
Cooperation in research	Collaborate with college and research institution (R1) Periodic training conducted by experts and scholars (R2) Collaborate with other enterprises (R3)
Innovation capacity	New products (A1) New patent (A2) Breakthrough in technology (A3) Market share of new product (A4) R&D accomplishment on time (A5) Improvement of innovation capability (A6)

technologies [9]. Under the pressure of fierce competition in the market, technical cooperation is the way to shorten product development time, to reduce costs as well as to move towards to international market and thus obtain emerging technologies. Besides, the huge development cost force enterprises to carry out technical cooperation. Cooperation with other enterprises, colleges and scientific research institutions, has become effective approach to improve efficiency of innovation.

H7: Cooperation in research has an effect on innovation capability.

The model we discussed later is established based on the above hypotheses.

3.3 Establishment of Evaluation Indicators

We design the indicators for the five factors and innovation capability based on the existed indicators and discussed with the members of research group. The established evaluation indicators are shown in Table 1.

3.4 Establishment of SEM Model

Structural equation model (SEM) is a method to establish, to estimate and to test causality model, which is a kind of technology that integrates measurement and analysis [11]. Based on the previous hypotheses, we establish the theoretical model (shown in Fig. 1). The boxes represent the influencing factors while the direction of arrows represent paths of effect relationship. In addition, the parameters above the arrows represent influence coefficients.

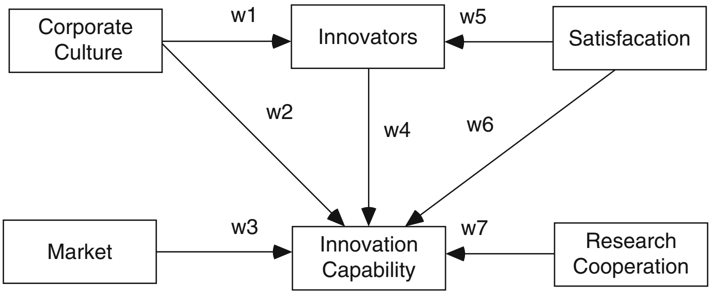

Fig. 1 Path diagram of SEM

4 Empirical Analysis

Since the population of equipment manufacturing enterprises in Guizhou is large, we thus select the equipment manufacturing enterprises in Guizhou province as a case for empirical analysis. Guizhou province is striving to promote implementation of the strategy to achieve a strong industrial province. The achievements of this study would make a positive contribution to the development of equipment manufacturing in Guizhou.

The evaluation indicators are integrated into questionnaire which is distributed to the employees in the equipment manufacturing enterprise in Guizhou. Employees are typically asked whether they agree or disagree with a statement. Responses are range from “strongly agree” to “strongly disagree” with five total answer options. Each option is ascribed a score, for instance, 1 refers to strongly disagree while 5 refers to strongly agree. The survey was performed in the following steps: small-scale distribution of questionnaire, interview, modification of questionnaire, and large-scale distribution of questionnaire. 100 questionnaires were distributed to the equipment manufacturing enterprises in Guizhou and 90 feedbacks were collected. Among them, 71 are valid and the valid rate is 79 %.

4.1 Reliability Test

The reliability of the collected data should be examined before model-fitting. Reliability examination adopts a typical and reliable method, measuring the Cronbach α coefficient. According to the standard of Nunnally, $\alpha > 0.9$ indicated a very high reliability; $0.7 < \alpha < 0.9$ referred to high reliability, $0.35 < \alpha < 0.7$ suggested medium reliability, and $\alpha < 0.35$ meant low reliability [12]. Meanwhile, the corrected item total correlation coefficients should be more than 0.35. We used SPSS 17.0 software to examine the internal consistency reliability of scale. Results are listed in Table 2. The results suggests that $\alpha = 0.944$ and standardized $\alpha = 0.942$, which indicates high reliability of the questionnaires.

Table 2 Reliability statistic

Cronbach's Alpha	Based on standardized items Cronbach's Alpha	Items
.944	.942	27

Table 3 Item total statistic

Item	Corrected item total correlation	Deleted item Cronbach's Alpha
C1	.337	.945
C2	.584	.943
C3	.663	.941
C4	.571	.943
M1	.587	.942
M2	.622	.942
M3	.707	.941
M4	.320	.945
I1	.740	.941
I2	.748	.941
I3	.677	.941
I4	.194	.945
I5	.228	.945
S1	.496	.943
S2	.648	.942
S3	.658	.942
S4	.614	.942
S5	.621	.942
R1	.617	.942
R2	.770	.940
R3	.682	.941
A1	.634	.942
A2	.524	.943
A3	.757	.940
A4	.726	.941
A5	.681	.942
A6	.737	.941

As shown in the Table 3, the corrected item total correlation coefficients of the four shadow items (C1, M4, I4 and I5) are less than 0.35, it means that the four indicators show low correlation with others. Thus they should be safely removed.

4.2 Model Fitting

We apply AMOS7.0 to analyze data. In this study, we choose maximum likelihood estimation to calculate data and modify the model according to the parameters given by AMOS. Through several times of modification, optimal model is obtained and shown in Fig. 2. The indices of optimal model fitting are shown in Table 4.

4.3 Model Evaluation

Compared with the theoretical model, emergence of the new paths and the deletion of the original paths are newly added into the optimal model, which is ascribed to

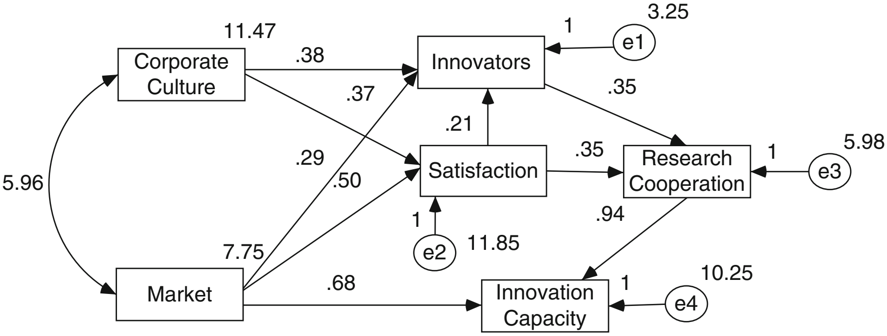

Fig. 2 Optimal model

Table 4 Model fit summary

Indices	χ^2/df	RMSEA	CFI	NFI	IFI	TLI	GFI	AGFI
Value	1.067	0.033	0.999	0.980	0.999	0.996	0.975	0.894
Ideal values	1 ∼ 3 [13]	<=0.08 [14]	>=0.9	>=0.9	>=0.9	>=0.9	>=0.9 [15]	>=0.9 [15]

the adjustment of model paths according to parameters given by the AMOS. On the basis of optimal model, we find some new relationships among the factors, and original hypotheses are also verified.

According to the test results shown in Table 4, it is easily to figure out that all indices satisfy the requirements except for AGFI whose value is slightly less than 0.9. The AGFI equals to adjusted R square in multiple regression analysis. Its value will be affected by the number of estimated parameters. The more parameters will be estimated, the bigger value of AGFI [11]. The AGFI value is slightly less than the ideal value. We reckon the reason would be the insufficiency of parameter estimation. Considering that the value of AGFI is slightly varying with the ideal value and the rest of indices are nicely fulfill requirements, we argue that the optimal model is applicable and efficaciously to fit original data.

4.4 Hypothesis Test

The estimated path coefficients of the optimal model are shown in Table 5. The values of P are less than 0.05 while values of CR are more than 1.96, which indicate that nine paths of the optimal model go through test. All of the path coefficients are greater than zero, indicating that each path is a positive correlation. In this model, the new paths include corporate culture to employees' satisfaction, market to employees' satisfaction, market to innovators, employees' satisfaction to cooperation in research, innovators to cooperation in research. It shows that market

Table 5 Estimates

Path	CR	P	Estimation
Culture → Satisfaction	2.344	0.019	0.297
Market → Satisfaction	2.610	.009	.331
Satisfaction → Innovators	3.295	***	.281
Culture → Innovators	4.479	***	.420
Market → Innovators	2.744	.006	.260
Satisfaction → Cooperation	3.885	***	.434
Innovators → Cooperation	2.898	.004	.324
Cooperation → Capacity	7.025	***	.584
Market → Capacity	4.243	***	.353

"***"represent p <= 0.001

Table 6 Effects estimates

Path	Direct effects	Indirect effects	Indirect effects
Market —> Innovators	.260	.093	.353
Market —> Satisfaction	.331	0	.331
Market —> Cooperation	.0	.258	.258
Market —> Capacity	.353	.151	.504
Culture —> Innovators	.420	.083	.503
Culture —> Satisfaction	.297	0	.297
Culture —> Cooperation	0	.293	.293
Culture —> Capacity	0	.171	.171
Satisfaction —> Innovators	.281	0	.281
Satisfaction —> Cooperation	.434	.091	.525
Satisfaction —> Capacity	0	.307	.307
Innovators —> Cooperation	.324	0	.324
Innovators —> Capacity	0	.189	.189
Cooperation —> Capacity	.584	0	.584

and corporate culture have a direct impact on personnel, and personnel have a direct impact on cooperation in research. These relationships are not taken into account in the former assumptions. Besides, three paths, corporate culture to innovation capacity, innovators to innovation capacity, employees' satisfaction to innovation capacity, have been removed, which represent that corporate culture, innovators and employees' satisfaction are not the direct factors affecting innovation capacity, but are indirect factors.

Table 6 interprets the influence coefficient of each path, it can be concluded that cooperation in research is a direct factor and has the greatest impact on innovation ability of enterprise. The total influence coefficient is 0.598, indicating that when other conditions remain unchanged, "innovation capacity" can upgrade a total of 0.589 units with one unit increase of "scientific cooperation". The second largest factor that impacts innovation capacity is market. The total influence coefficient is 0.504. In Addition, the effect of corporate culture on innovators and the effect of employees' satisfaction on cooperation in research are significant since they both have a total influence coefficient higher than 0.5, which signify the favorable corporate culture would be a incentive for innovators and employees' satisfaction is a guarantee for efficient cooperation in research.

5 Conclusion

Based on the existing research on equipment manufacturing enterprises, methods, such as literature analysis, theoretical studies, spot investigation and questionnaire, are integrated to analyze the problems and shortcomings in the research. Several results are obtained:

1. From the aspect of internal and external factors, this article put forward five main influencing factors that affect the innovation capability of Chinese equipment manufacturing, including corporate culture, market, innovator, employees' satisfaction and cooperation in research.
2. Based on the theoretical analysis, we assume the relationship between influencing factors and innovation capability, the relation model of "influencing factors – innovation capability" is established.
3. Through empirical analysis, model fitting, model modification and hypothesis testing, the correlation between influencing factors and innovation capacity of the equipment manufacturing industry in Guizhou Province is achieved.

The results explain that cooperation in research and market are two important factors influencing the innovation capability of equipment manufacturing enterprises in Guizhou Province. Therefore, in the future, enhancing cooperation in research and improving market competitiveness are the primary task for Guizhou province to develop and to reform the equipment manufacturing industry. Initially, enterprises should make full use of local resources to establish good relationship of communication, exchanges, cooperation with local colleges, universities as well as research institutes, holding meeting regularly to provide staff with a good platform to exchange experience relating research; Secondly, effective approaches should be taken to strengthen pre-market research of new product development in order to reinforce the competitiveness of products in the market and to add value to products. Furthermore, enterprises should spare no efforts to cultivate a good innovative environment for employees in order to attract more research talents. Meanwhile, the improvement of working conditions and rationality of management system should be highlighted to increase employee's job satisfaction. The five influencing factors proposed in this paper have strong relevance between each other, the failure to balance the five factors would lead to the abnormal development of the enterprise and thus enhancing the innovation capability will be difficult.

Acknowledgment This research is supported by Humanities and Social Sciences Foundation of Education Department of Guizhou Province (project number: 10JD19) and International Cooperative Project of Guizhou province (project number: (2012)7007).

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Research on Simulation of the Emergency Information Dissemination Based on Netlogo

Hui-jing Xie, Ying-zi Tan, and Ying-qiu Xu

Abstract This paper analyzes the influencing factors and participation of emergency information dissemination, and constructs a simulation model of emergency information dissemination, including the rules of subjects' interaction and their attribute functions. It develops the simulation algorithm flowchart and uses '7.23EMU Accident' data as the initial data of simulation. The dynamic simulation process includes the rumor spread and the influence of opinion leaders. The simulation results identify which attributes are the main factors of emergency developments, and provide effective methods to control the emergency development.

Keywords Emergencies • Information dissemination model • Multi-agent modeling • Netlogo • Opinion leaders • Rumor dissemination

1 Introduction

It is quite important to study the emergency information dissemination law [1] to improve the level of information communication and processing, thereby enable effective responses to the emergencies in preventing potential damage. Previous research addressed on the theories of dissemination model, and provided classical models of information dissemination [2]. Lasswell's "Five W Model" developed the basic model of information dissemination. Shannon and Weaver [3] introduced the concept of noise in their "linear model" as a new approach based on to the original

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model. However, none of those two models revealed the bidirectional interactive characteristic of public communication. Osgood and Schramm's "loop model" highlighted the interactive characteristic of the public communication, and regarded both sides as the key of communication behavior. However, this method also bears some shortcomings in that- it put different communication subjects in an absolutely equal relationship, which is inconsistent with the phenomenon of opinion leaders in the real world. In another word, it only reflected the characteristics of point-to-point communication, which was not sufficient to reflect the public communication process. In 1970, Defleur proposed "interactive process model" that incorporated noise, feedback elements, links and channels to the basis of linear model, and suggested that noise had an effect on any aspects of communication and feedback process. This was a model that explained spread process more comprehensively. In 2004, Fiona Duggan and Linda Banwella brought forward the crisis information dissemination model [4] from the perspective of information senders and receivers. Although the model classified the influencing factors as internal and external factors, the dissemination process was not sufficient.

The advent of Internet era makes huge challenges to the traditional spread mode. The interactive platform makes everyone become the driving force of the information dissemination [5]. Interactive communication on internet is similar to that in real life. Based on previous research [6], this paper is mainly about the information dissemination on the web, not only considering the internal and external factors that affect senders and receivers, but also the process of information dissemination, and then puts forward a new model. The model simulates the interpersonal interaction of views, and analyzes the influencing factors such as the authority of opinion leaders [7] and seditiousness of rumors [8] from the a micro perspective. In the end, it gives simulation results and analysis based on Netlogo [9] platform.

2 Model Construction of Emergency Information Dissemination

2.1 Model Construction of Information Dissemination in an Emergency

According to Fiona Duggan and Linda Banwell's crisis information dissemination model, the influencing factors are classified as internal and external factors, including opinion leaders, willingness to accept new knowledge, target information, and assumptions, etc. The life cycle of dissemination is classified as precursor period, diffusion period, outbreak period and recovery period. Based on the influencing factors, this paper introduces the concept of the dissemination process, establishing a brand new emergency information dissemination model, as shown in Fig. 1.

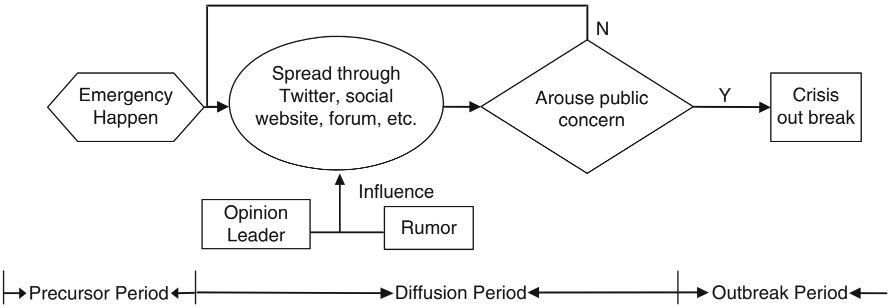

Fig. 1 Model of emergency information dissemination

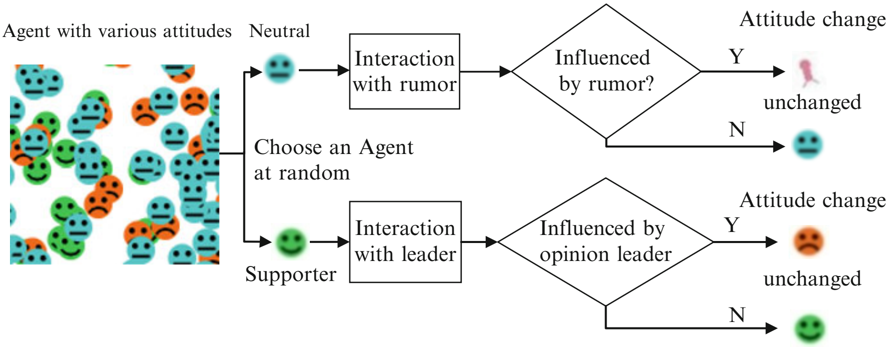

Fig. 2 Model of information interaction based on agent (Color figure online)

The dissemination cannot be tested in the real life; thereby, the most effective method is computer modeling and simulation. Social system is a complex system, taking into account the diversity of individuals, this article uses Agent-based modeling and simulation methods [10] to study the information dissemination.

2.2 *Agent-Based Information Dissemination Model*

The basic idea of modeling: Simulate the person in society as a computer Agent [11]. Simulate the interaction behavior among people's views as the behavior of Agent. Introduce the interaction rules, in order to decide whether an individual will change the idea and the level of change. After repeated view interaction, the macro phenomenon of public opinion will be observed from the groups. As shown in Fig. 2, this method can effectively answer the question of how micro individual views aggregate to a macro public opinion.

2.3 Introduction of Netlogo

NetLogo was developed by Uri Wllensky sponsored by U.S. National Science Foundation in 1999, aiming at providing powerful computer-aided tools to scientific research and education. The NetLogo1.0 version was released in 2002, and fully implemented in Java programming, available on different platforms. NetLogo is particularly appropriate for time-series modeling of complex systems. It comes with a variety of Agent types such as turtle, patch, and link, etc. The modelers can send directives to hundreds of thousands of independent running Agents, which makes it possible to explore the connections between individual behaviors on the micro level and macro mode, emerged by the interactions of many individuals.

2.4 Establish Agent Model

In public opinion spread, the attitudes that most people will choose to incline to are often influenced by others [12]. This article focuses on individual Agent modeling. People in real life will be regarded as the independent Agents. Rumors and opinion leaders will be regarded as the super objects which are independent of the Agent, being able to exert influence on individual Agent to change its attitude. Several characteristics related to information dissemination include attitude, conformity, credibility and authoritativeness [13].

1. Attitude. The public holds three kinds of attitudes towards information: support, neutral, and opposition. In the society, people's view does not start out clear and unequivocal. Because of the influence from media or public, it will gradually become clear and firm. Therefore, this paper draws randomly a real number on interval (0, 1) to represent individual opinions, with (0, 0.33) representing the opposition, (0.33, 0.67) representing the neutral, and (0.67, 1) representing the support.
2. Conformity. The level of individual following the crowd is influenced by a variety of factors, such as individual status, personality, psychology and extent of information controlling. This paper draws randomly a real number on interval (0, 1) to represent individual conformity, with (0, 0.33) representing the firm attitude, (0.33, 0.67) representing the vacillating attitude, and (0.67, 1) representing the easily-changed attitude.
3. Credibility. The individual's credibility is his evidence. The higher the credibility is, the greater the influence will be. This paper draws randomly a real number on interval (0, 1) to represent individual credibility, with (0, 0.33) representing unlikelihood, (0.33, 0.67) representing a little convincing, and (0.67, 1) representing likelihood.

Table 1 Characteristics of various subjects

Subjects	People	Rumor	Opinion leaders
Characteristics	Attitude, conformity, credibility	Attitude, credibility	Attitude, credibility, authoritativeness

4. Authoritativeness. The more authoritative the opinion leader is, the greater the influence will be. This paper draws randomly a real number on interval (0, 1) to represent authoritativeness of opinion leader, with (0, 0.33) representing less authoritative, (0.33, 0.67) representing more authoritative, and (0.67, 1) representing very authoritative.

During the spread and outbreak period of an event, there are three main types of subjects: people, rumors makers and opinion leaders. Table 1 shows the characteristics of the three subjects.

2.5 Interaction Rules Between Subjects

Interaction rules of agents can reflect the factors that affects agents' opinions. Assume $A_i(t)$ is the attitude of subject i, $T_i(t)$ is the credibility, and a is the threshold of interaction (see reference [14], this paper takes $a = 0.34$). At time t, if $|A_i(t) - A_j(t)| < a$, there is few attitudinal difference between subject i and subject j. If $T_j(t) > T_i(t)$, subject j can affect the attitude of subject i. At time $t + 1$. The state transition equation of subject i is shown in equation 1:

$$\begin{aligned} A_i(t+1) &= A_i(t) + \big(A_j(t) - A_i(t)\big) \cdot g_i(t) \\ T_i(t+1) &= T_i(t) + \big(T_j(t) - T_i(t)\big) \cdot g_i(t) \end{aligned} \tag{1}$$

$g_i(t)$ represents the probability of subject i affected by subject j, such as the probability of public attitudes affected by rumor, which is directly proportional to conformity, inversely proportional to the credibility of public, and directly proportional to the seditiousness of rumors. The probability of public attitudes affected by opinion leaders is directly proportional to conformity, inversely proportional to the credibility of public, and directly proportional to the credibility and authoritativeness of opinion leaders [11].

In the state between the above two, subject i do not change the attitude, the state transition equation is shown in Equation (2):

$$A_i(t+1) = A_i(t); \qquad T_i(t+1) = T_i(t) \tag{2}$$

3 Emergency Information Dissemination Simulation and Results Analysis

This article uses the information diffusion process of “7.23EMU Accident” [15] as an example. The official explanation that the accident is caused by lightning strike has made a great disturbance online. This article collects the number of browses and replies to the “5 questions of 7.23EMU” topic from 10 am to 8 pm on July 2011, 25th. It scales down the actual data to 3.33 %, as origin data for simulation. It turned out that there were 50 people who believed the “accident cause”, namely “supporter”; 270 people who did not believe it, namely “opposer”; the other 320 people is the so-called “neutral”.

3.1 Interactive Simulation in Rumor Area

To test which factors will affect the dissemination in rumor area firstly requires alternating the parameters of rumor (such as seditiousness, etc.). The initial parameters are shown in Table 2.

1. While the rumor’s attitude takes value in (0, 0.33), it means that rumor maker didn’t believe the “lighting strike” cause. The interactive simulation in rumor area is shown in Fig. 3, yellow area represents the rumor area, it shows that the number of influenced people is increasing.

   Figure 4 shows the change in population sizes influenced by rumor. The number of neutrals and opposers are reducing, number of supporters remains the same, and the number of influenced people continues to increase. Finally, 419 people change their attitudes by the rumor. It shows that rumors on Internet mainly influence two kinds of people: one is the people whose attitudes are similar with rumors, and the other is the neutrals whose attitudes are wavering;

Table 2 Set initial parameters

Parameters	Value
Attitude	Random number on (0,1)
Initial opinion distributing (support, neutral, opposition)	50:320:270
Number of agent	640
Conformity	Random number on (0,0.51)
Credibility of rumor (Seditiousness)	Random number on (0,0.7)

Subjects	People	Rumor	Opinion leaders
Characteristics	Attitude, conformity, credibility	Attitude, credibility	Attitude, credibility, authoritativeness

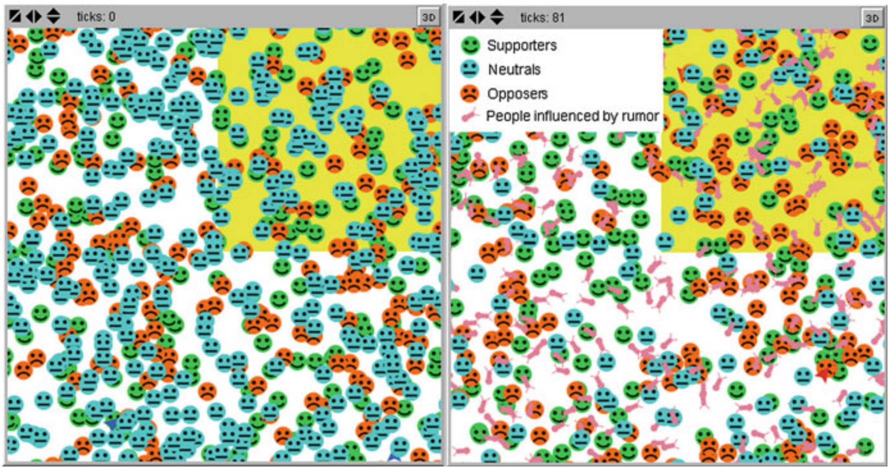

Fig. 3 Interactive simulation process in rumor area (Color figure online)

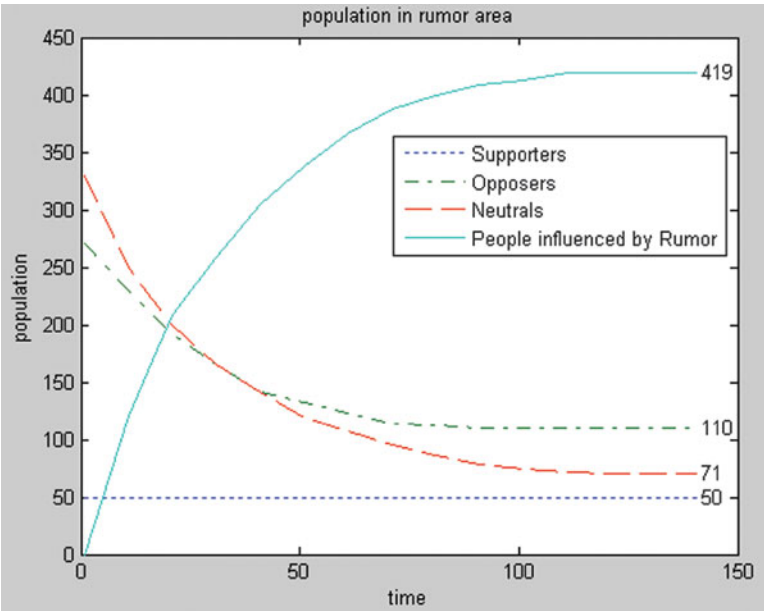

Fig. 4 Change of population sizes in rumor area

on the other hand, the number of people whose attitudes are obviously different from rumors (believe the “lightning strike” cause) remains the same. It shows that these supporters whose attitudes are very firm, hardly been influenced by rumors, always opinionated.

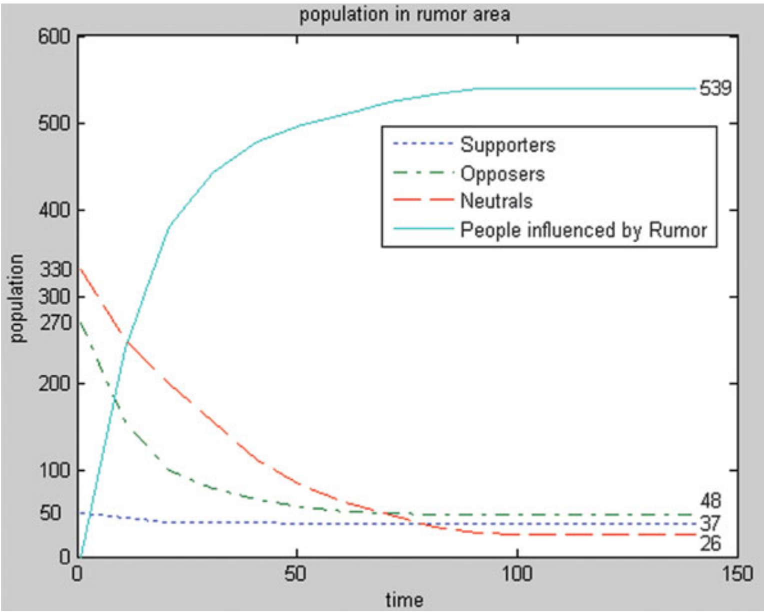

Fig. 5 Change of population sizes in rumor area, after increasing rumor's credibility

2. Increase the credibility of rumor to (0.7, 1), while other parameters remain the same. After 140 times of evolution, the changing process is shown in Fig. 5. The influenced population continues to rise, faster than prior process, and 120 more people are influenced than prior process. It shows that the higher the credibility is, the faster the dissemination is; on the other hand, not only neutrals but opposers and those people whose attitudes are obviously different from rumors are also influenced by rumors. It shows that the higher the credibility of rumor is, the wider the coverage of rumor area will be.

3.2 Interactive Simulation with Opinion Leader

To test which factors will affect the spread with opinion leader firstly requires alternating the parameters of opinion leaders (such as authoritative, etc.).

1. While the opinion leader's credibility takes value in (0, 0.7), attitude takes value in (0, 0.33), it means opinion leader didn't believe the "lightening strike" cause. After 140 times of evolution, the changing process is shown as Fig. 6 below. Influenced population continues to rise. It shows that a lot of people have been influenced by opinion leaders.

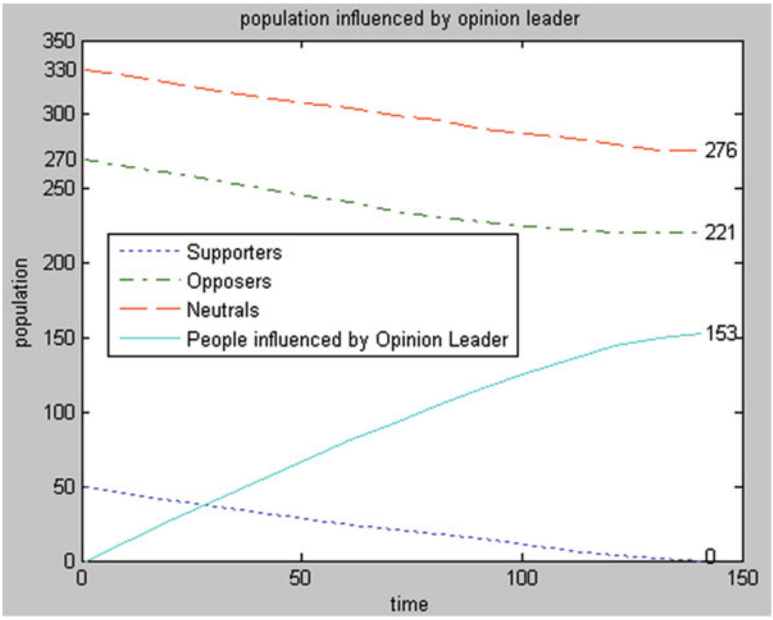

Fig. 6 Change of population sizes influenced by opinion leader

2. Figure 7 shows the change in population sizes when decreasing the credibility (authority) taken to be a random number on (0, 0.51), while other parameters remain the same and after 102 times of evolution. The size of the influenced population is significantly reduced. It shows that the authority is the determined factor of dissemination, the higher the credibility of information is, the more the people will believe.

The result above shows that opinion leader with wide influencing power and high authority is not just an ordinary person, but an critical participant to guide public opinion in the process of emergency information dissemination. Opinion leader is an invisible hand that boosts the process of emergency information dissemination. Their attitudes are essential. If they criticize or question the incident, the incident might turn into a huge public crisis under the additive effect of emergency dissemination.

4 Conclusion

The paper addressed the topic of the rule of emergency information dissemination. It firstly analyzes the influencing and participant factors, and then constructs a simulation model of emergency information dissemination, using Netlogo platform

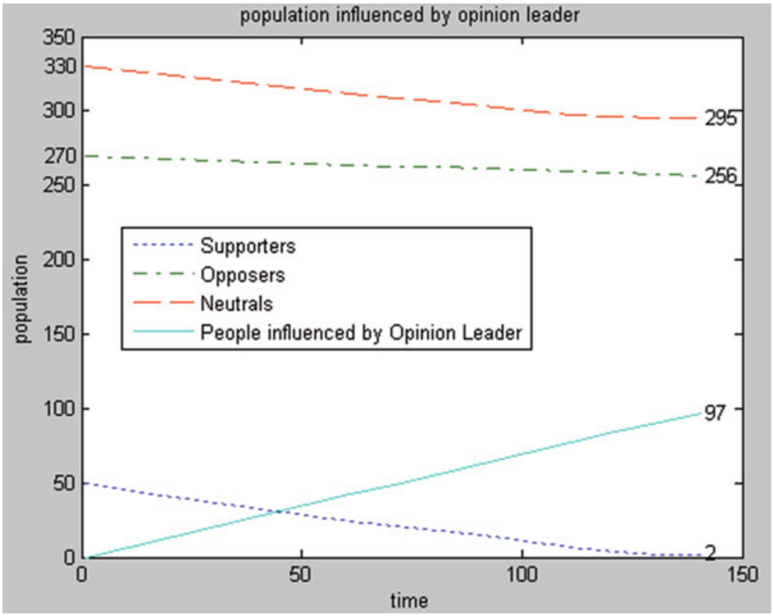

Fig. 7 Change of population sizes influenced by opinion leader, after decreasing opinion leader's credibility

to perform the dynamic simulation. The simulation process includes rumor spread procedure and the influence of opinion leaders. The paper finally provides simulation results in graphs. More can be done on constructing the model of interpersonal relationship in a more complex network and combine it with the study of the dissemination dynamics to make it more realistic. It can specify a geographical location or population distribution to make the model more realistic and practical.

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A Research on Strategies for the Sustainable Development of Tourism Service Products Based on the Theory of Service Management—A Case Study in Brocade of Hainan Li Nationality

Xiao-huai Wu and Li-juan Zhang

Abstract Based on the theory of Service Management, this paper takes the sustainable development for Ethnic Minorities in China Programme-Li Brocade of United Nations Development Programme (UNDP) as the case to analyze the specialty of Li-Brocade as a tourism service product. Furthermore, the authors obviously present the effective sustainable development strategies and approaches of tourism product and protection according to the characteristics of Brocade of Hainan Li Nationality.

Keywords Li-Brocade • Service management • Sustainable development

1 Introduction

The theory of Service Management is gradually formed and developed accompanied by the recognizing and understanding of the service characteristics and service management in western management academia. It was introduced into China about 1990s. Into the 1980s, with the concept of Perceived Service Quality [1], Service Quality Model [2], the academic circles had a new understanding of the service quality. Until Normann (1984) combined the concept of Moments of Truth with the theory of Service Management, the researches on service became flourishing [3]. Since the 1990s, the increasing researches, one of which is the Service Profit Chain model by Heskett et al. (1994) received widespread attention, began to focus on the relationship between the various elements of the service

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management [4]. The Service Profit Chain represents a customer-centered mode of service management, combining of the internal and external of marketing. It is from the customers' viewpoint to re-examine the long-term profitability of the service enterprises.

2 The Application of the Service Management Theory into the Sustainable Development of the Tourism Products Belonging to Intangible Cultural Heritage

The State Council of China wrote two batches of (1,028 items) state-level intangible cultural heritage in the list in 2006 and 2008, respectively. For the protection of the intangible heritage, the central government and provincial finances have invested a total of RMB 1.789 billion [5]. A new question about how to constantly utilize the intangible heritage as a tourism resource has been aroused consistently with its protection. In this paper, we position Li-Brocade in Hainan Province as a special tourism commodity, through the theory of Customer Perceived Service Quality and Service Profit Chain model in the Service Management theory to study the specific strategies and approaches to carry out the sustainable development of tourism resources in the intangible cultural heritage.

Li-Brocade is one of the earliest cotton textiles in China. Most of it was for women's skirts and other daily necessities. Li-Brocade was endangered within Chinese Great Cultural Revolution [6], however, Li-Brocade was listed in the national intangible cultural heritage lists as the first batch in 2006.

Many scholars put forward a proposal to protect Li-Brocade and Li culture or ethnic traditional heritage of arts and crafts from different angles. Zhao Quanpeng (2000) identified certain appropriate measures to preserve national culture of Li or Miao nationality in Hainan Province [7]. Zhao Yihung (2004) launched the importance of innovation in the process of Li-Brocade's heritage and development [8]. Wang Wei (2008) suggested several approaches to exploit Li-Brocade as for the problems was figured out when he surveyed the teaching stations in Fanmao Village [9]. Su Qin (2009) best illustrated with the case of Jinkeng Hongyao Rice Terraces Scenic Area of Guilin that the strategies to the sustainable development of the national culture hinged on the physical aspect, spiritual aspect and regulation system under the background of tourism [10]. Xiong Hongli (2010) investigated the contemporary modalities to which Li-Brocade could be transferred via the design perspective [11]. Zhang Jingrong (2010) indicated the specific measures and the issues of the Rural Tourism Development in the context of international tourism of Hainan [12].

On 12 Dec. 2011, United Nations Development Programme (UNDP), China International Center for Economic and Technical Exchanges (CICETE), Wuzhishan Municipal Government, Hainan Province signed a project document on Sub-project on Protection and Development of Li – Brocade in Hainan Province under

Culture-based development for Ethnic Minorities in China Programme (the Project for short). We, as the members of the project, visited Fanmao village to conduct the field investigation. Li-Brocade is a variable product rather than a changeless product. While the overall cultural tourism in Fanmao Village is developed, Li-Brocade, a tourism commodity, should be effectively made use of both for income and culture exchange. Also, the heritage of Li-Brocade is not able to be separated from the community public participation.

3 The Analysis of the Characteristics of Li-Brocade by the Theory of Customer Perceived Service Quality

Li-Brocade has been viewed as an effective development of tourism resources, which should be integrated with other intangible elements such as arts, culture, technique, production and service rather than existing like a simply tangible product. It is such a product that it will further enhance the customers' perceived quality and expand its market. Gronroos (1982) divided the quality of service into "technical quality" and "functional quality" according to the basic theory of cognitive psychology [1]. If customers' actual experience on the service quality meets or exceeds their expectations, they will feel the overall quality of the service is satisfactory. In contrast, they will feel the quality is poor. The ultimate goal of the marketing of Li-Brocade is to pursue the customer satisfaction for this reason.

3.1 The Technical Quality of Li-Brocade

The definition of "technical quality" refers to the results of the service production process, also known as the quality of results. Clearly, it is the customers' demands for the service hardware (facilities and equipment), service hours, standards of service quality, and atmosphere provided by enterprises.

1. The service hardware of Li-Brocade. At present, Fanmao village could hardly provide the complicated infrastructure and facilities to tourists, such as bumpy roads, poor sanitation, no parking, no dining and entertainment. It is nothing without upgrading the level of these facilities, even though there is good quality Li-Brocade and excellent service in the village.
2. The service places of Li-Brocade. The outdoor decoration, lighting, acoustic, and indoor comfort of the recent two teaching stations are relatively undeveloped. Besides, additional services and products should be introduced as soon as possible.
3. The service atmosphere of Li-Brocade. The overall layout of Fanmao Village is disorganized and it should be rearranged in order.

3.2 The Functional Quality of Li-Brocade

It refers to the receivable services to customers and their experience in the process of production and consumption, also known as the quality of the procedure. The appearance and performance, etiquette, service attitude, service procedure and service skills of the local villagers that will be inevitably experienced by customers should be trained to improve service and marketing awareness.

4 The Strategies and Approaches of Sustainable Development of Li-Brocade Based on the Service Profit Chain Model

The service profit-chain model was proposed by Professor Heskett (1994) of Harvard University in the USA. The heart of customer service value (CSV) is the customer value equation (Fig. 1) [4].

As shown in the above equation, the customer loyalty is to determine the profits and development of an enterprise; the customer satisfaction is to determine the customer loyalty; the value of consumption is to determine the customer satisfaction; the labor productivity is to determine the value of consumption; the employee loyalty is to determine the labor productivity; and internal service quality is to determine the employee satisfaction and loyalty.

Putting the theory into practice, the community of FanMao Village need boost the internal service quality, thereby reaching the villagers' satisfaction of those who take part in the project of tourism development benefiting from it, as long as Li-Brocade chases both profits and sustainable development. Only in the way of taking the community-led (participatory) mode, will the sustainable development be successful.

Specific strategies and approaches as follows:

4.1 Development of Li Brocade Cultural Community Tourism in Fanmao Village

The overall objective is to be involved with building Fanmao Village as "the hometown of Li Brocade". The resources of Fanmao Village tourism: Fanmao

$$CSV = \frac{SU+SQ}{SP+SC}$$

SU - service utility SQ - service quality
SP - service price SC - service cost

Fig. 1 Customer value equation

Village is located in the west part of Wuzhi Mountain area of Hainan Province. There are five natural villages (Fanmao, Fujian, Shifen, Shihao, Fanba) under the jurisdiction of Fanmao Village. The community population is 330 householders with 1,219 people.

The first cooperative of Li Nationality in Hainan was established in Fanmao Village in Chongshan Town of Wuzhishan in 1954. From 1960s to 1970s, becoming a “Pilot Village” brought it the fame. It was visited by many leaders, such as Zhude, Xu Shiyou. Fanmao Village, was known as the “Li-Brocade Village”, has vigorously develop Li-Brocade industry since the reform and opening up, which has a state-level intangible cultural heritage inheritor of Li-Brocade-Liu Xianglan, two teaching stations of Li Brocade.

The plan of the development: To rely on the influence of Wuzhi Mountain and the intangible cultural heritage – Li-Brocade, the local government should exploit more appropriate projects. The earnings from the tourism could be used in the heritage protection to achieve the sustainable development of Li-Brocade.

The strategy of the developing and positioning: The hometown of Chinese Li Brocade.

The functional layout: Under the influence of the resource conditions, functional roles and the new city urbanization, the village is proposed to plan the layout of “one center, two zones, and three districts”. “One center” indicates a service center of village culture and entertainment; “two zones” present a cultural experience and exhibition zone of Li-Brocade and a travel and leisure zone with native folk houses; “three districts” refers to a comprehensive reception district, a rural tourism district of Li Nationality, and a singing and dancing customs experience district.

4.2 To Create a Series of Tourism Products

The Current situation of Fanmao Village is initially able to provide the original products that may be finely processed into commodities.

The main plan of development of Fanmao Village

- To support Fan Mao village to gradually form a diversified tourism product system around the core-Li-Brocade.
- According to the need of Hainan international tourism, the crafts and souvenirs of Li Brocade should be extended widely.
- The measures of development: Fanmao Village could adopt the combination style measures to organize the experienced brocade artists, inheritor of Li Brocade experts to study intensively on Li-Brocade. Based on the elaborative study, teaching stations would cultivate weavers’ creative capacity of Li Brocade. Therefore, it may also combine and bring along other products, such as Li-songs and dances,

5 Conclusion

The development and protection of Li-Brocade are complementary to each other. It is essential to take the "productive protection" measure for the ethnic craft-Li-Brocade with economic development. Based on the theory of customers' sentience and the service profit chain model, Li-Brocade as a special commodity of tourism builds up the community-led (participatory) mode of development and satisfies the demands of the market is an effective strategy of accomplishing the products' development of Intangible cultural heritage tourism service and enhancing the tourism quality of community.

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The Application of System Dynamics in Financial Management

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Abstract The current researches of financial management mainly focus on analysis of rationality of financial management target or the application, advantages and disadvantages of a certain management method in financial management. It is rarely seen that financial operating factors, their interactions and influence on financial operation have been analyzed in a systematic way. In order to avoid partial analysis on the irrationality of a certain policy and the limitation of static analysis of irrational financial structure, this thesis puts forward a financial management method based on system dynamics.

Keywords Financial management • Interaction • System dynamics

1 Introduction

As a crucial sub-system, financial system exits in a certain economic system. To some extent, the normal operation or development of an economic system relies on steady run of its financial system. Surplus is considered as the most direct index to evaluate the operational efficiency of an economic system. Therefore, it is of significance for the management of an enterprise to make financial sub-system in a state of net inflow, which indicates the target of financial management.

Currently, among researches concerning financial management, qualitative analysis on target rationality, methods application and their advantages and disadvantages are commonly seen [1]. However, all these researches show their impotence when they are faced with high-order, non-linear and complex systems. For this purpose, the thesis aims to figure out such problems on the basis of system

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dynamics. At the same time, it is supposed to raise scientific foundation, efficient countermeasure and clear management approach for realizing object optimization of complex financial systems.

2 Methodology

System dynamics namely is to make dynamic analysis in a systematic way [2]. System dynamics aims to study the influence made by certain index or countermeasure on different parts or the entire system, thus to provide more reliable and convincible basis for researches on political rationality. System dynamics models may be used to describe the dynamic complexity of a system, upon that the research can be made in a meticulous way. Thus, the archetype can be found to form archetype generating sets. Then, the whole system can be analyzed when these archetype generating sets are sorted and integrated. This method shows us an analyzing view from large to small and then from small to large, which allows us to get clear operational details as well as leverage solution in a system.

A. Set up rate variable fundamental in-tree model

First, level rate variable system is set up according to its specific conditions: $\{(L_1(t), R_1(t)), (L_2(t), R_2(t)), \ldots, (L_n(t), R_n(t))\}$, L stands for level, R stands for rate, C stands for oriented chain consisted of auxiliaries. Then, strongly simplified rate variable fundamental in-tree model is as follows [2, 3] (Fig. 1):

B. Get the minimal archetype generating set of the in-tree model

(1) Get the second-order minimal archetype

Hypothesize matrix:

$$A_{n\times n} = \begin{pmatrix} 0 & (R_1(t), C_{12}(t), L_2(t)) & \cdots & (R_1(t), C_{1n}(t), L_n(t)) \\ (R_2(t), C_{21}(t), L_1(t)) & 0 & \cdots & (R_2(t), C_{2n}(t), L_n(t)) \\ \vdots & \vdots & & \vdots \\ (R_n(t), C_{n1}(t), L_1(t)) & (R_n(t), C_{n2}(t), L_2(t)) & \cdots & 0 \end{pmatrix}$$

Hypothesize $a_{ij} = (R_i(t), C_{ij}(t), L_j(t)), i \neq j, i, j = 1, 2, \cdots, n$ Matrix upper and lower triangular elements multiplication:

$$\begin{aligned} F_2(A_{n\times n}) = ((&a_{12}a_{21} + a_{13}a_{31} + \cdots + a_{1n}a_{n1}) \\ &+ (a_{23}a_{32} + a_{24}a_{42} + \cdots + a_{2n}a_{n2}) + \cdots + a_{(n-1)n}a_{n(n-1)}) \end{aligned}$$

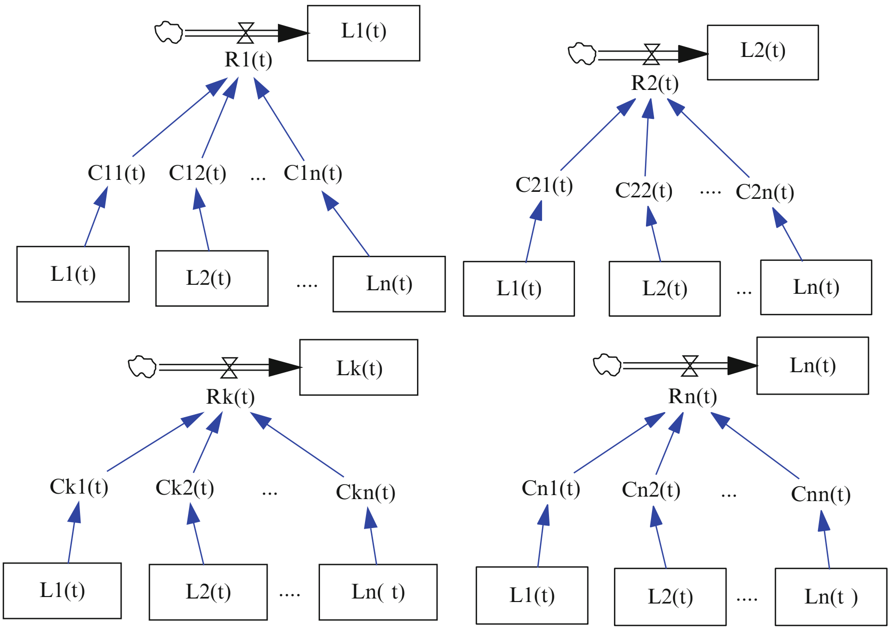

Fig. 1 Rate variable fundamental in-tree model $T_1(t), T_2(t), \cdots, T_n(t)$

Get all the second-order archetypes of $G_{12\cdots n}(t) = \overrightarrow{\bigcup_{i=1}} T_i(t)$, on condition that all the in-tree elements are in the second-order archetypes, all the second-order minimal archetypes form an archetype generating set. Otherwise, the following steps should be continued.

(2) Solve k-order ($3 \leq k \leq n$) minimal archetype

Hypothesize that after step (1), second-order minimal archetypes and in-tree generating set outside second-order minimal archetypes are

$$A_0(t) = \left\{ G_{i_1 i_2}(t) \middle| i_1, i_2 \in I_2 \subseteq \{1, 2, \cdots, t_0\} \right\} \quad \text{and} \quad \{T_{t_0+1}(t), T_{t_0+2}(t), \cdots, T_n(t)\}$$

respectively, do embedding operation of $G_{i_1 i_2}(t)$ and $T_{t_0+1}(t), T_{t_0+2}(t), \cdots, T_n(t)$,

$$G_{i_1 i_2 i_3}(t) = G_{i_1 i_2}(t) \overrightarrow{\bigcup} T_{i_3}(t), i_3 \in \{t_0 + 1, t_0 + 2, \ldots, n\}$$

If new third-order feedback loop comes into being in this process, $G_{i_1 i_2 i_3}(t)$ is the third-order minimal archetype. After this operation, if $T_{t_0+1}(t), T_{t_0+2}(t), \ldots, T_n(t)$ are in the third-order minimal archetype, the archetype generating set is composed of second-order and third-order minimal archetypes. The above steps should be repeated until all in-tree elements are in the minimal archetypes, and then we can get the archetype generating set.

C. Classify the minimal archetypes

Assuming that all the minimal archetypes coming from part B forms an archetype generating set

$$A(t) = \left\{ G_{i_1 i_2}(t), G_{i_3 i_4 i_5}(t), \ldots, G_{i_k i_{k+1} i_{2k}}(t) \right\}$$

The minimal archetypes in $A(t)$ are classified in accordance with "polarity of feedback-loop in archetypes" and "study object and research objective".

D. Get archetypes of pragmatic significance

Hypothesize

$$G_{xy\cdots z}(t) = \alpha_{i_2 i_2} G_{i_2 i_2}(t) \overrightarrow{\cup} \alpha_{i_3 i_4 i_5} G_{i_3 i_4 i_5}(t) \overrightarrow{\cup} \ldots \overrightarrow{\cup} \alpha_{i_k i_{k+1} \cdots i_{2k}} G_{i_k i_{k+1} \cdots i_{2k}}(t)$$

In which, $\alpha_{i_1 i_2}, \alpha_{i_3 i_4 i_5}, \ldots, \alpha_{i_k i_{k+1} \cdots i_{2k}} \in \{0, 1\}$, by giving coefficient 0 or 1, we can get a number of archetypes of pragmatic significance through permutation and combination.

E. Make feedback-loop analysis on complex archetypes

The newly increased feedback loop produced in the course of turning the minimal archetypes into complex archetypes is analyzed as well as their pragmatic significance.

F. Finally, the management guideline over complex system comes into being on the basis of making analysis on archetypes of specific significance using the thinking mode of simple archetype leverage solution.

3 Positive Analysis—Taking an Example of the Financial System of Privately-Run Colleges and Universities

Privately-run colleges and universities are the outcome of market economic structure. This kind of legal entities are allowed to make certain amount of profit with its income against expenditure [4]. Stable financial situation is a reliable safeguard for the efficient running of these colleges and universities [5, 6]. Then, the above method is applied to make an analysis on the financial management system of a certain privately-run college.

The definition and dimension of main parameter index composing the financial system are shown in Table 1.

In this table, L stands for level variable, R stands for rate variable. The enrollment expenses include advertising and publicity, complete index reward etc. Fundraising is consisted of income from cooperation between college and enterprise, government subsidy, contribution from individuals or social organizations. Expenses

Table 1 Definition and dimension of main parameter index

Variable	Definition	Dimension	Variable	Definition	Dimension
$L_1(t)$	Number of students	Person	$R_1(t)$	Variation of number of students	Person/year
$L_2(t)$	Number of teaching staff	Person	$R_2(t)$	Variation of number of teaching staff	Person/year
$L_3(t)$	Fixed assets input	10,000 RMB	$R_3(t)$	Variation of fixed assets input	10,000 RMB/year
$L_4(t)$	Enrollment expense	10,000 RMB	$R_4(t)$	Variation of enrollment expense	10,000 RMB/year
$L_5(t)$	Expense of consumable articles	10,000 RMB	$R_5(t)$	Variation of expense of consumable articles	10,000 RMB/year
$L_6(t)$	Fundraising	10,000 RMB	$R_6(t)$	Variation of fundraising	10,000 RMB/year
$L_7(t)$	Financial surplus	10,000 RMB	$R_7(t)$	Variation of financial surplus	10,000 RMB/year

of consumable articles include expenditure of daily office supplies, water and electricity, maintenance, sanitation etc. [7, 8].

Matrix with zero on the cross coming from rate variable fundamental in-tree model (omitted) is as follows:

$$A_{7\times7} =$$

$$\begin{pmatrix} 0 & (R_1,C_{12},L_2) & (R_1,C_{13},L_3) & (R_1,C_{14},L_4) & 0 & 0 & (R_1,C_{17},L_7) \\ (R_2,C_{21},L_1) & 0 & (R_2,C_{23},L_3) & 0 & 0 & 0 & (R_2,C_{27},L_7) \\ (R_3,C_{31},L_1) & (R_3,C_{32},L_2) & 0 & 0 & 0 & (R_3,C_{36},L_6) & (R_3,C_{37},L_7) \\ 0 & 0 & 0 & 0 & 0 & (R_4,C_{46},L_6) & (R_4,C_{47},L_7) \\ (R_5,C_{51},L_1) & (R_5,C_{52},L_2) & (R_5,C_{53},L_3) & 0 & 0 & 0 & 0 \\ (R_6,C_{61},L_1) & 0 & (R_6,C_{63},L_3) & 0 & 0 & 0 & 0 \\ (R_7,C_{71},L_1) & (R_7,C_{72},L_2) & (R_7,C_{73},L_3) & (R_7,C_{74},L_4) & (R_7,C_{75},L_5) & (R_7,C_{76},L_6) & 0 \end{pmatrix}$$

Second-order minimal archetypes $G_{12}, G_{13}, G_{17}, G_{23}, G_{27}, G_{36}, G_{37}, G_{47}$ are got through matrix upper and lower triangular elements multiplication. Here, rate variable fundamental in-tree $T_5(t)$ has not been in these minimal archetypes. Therefore, we make embedding operation on all second-order minimal archetypes and their rate variable fundamental in-tree. Then third-order minimal archetypes $G_{157}, G_{257}, G_{357}$ are got decided by the existence of new third-order feedback loop. By this time, all rate variable fundamental in-tree have been in the minimal archetypes. Consequently, we get the minimal archetype generating set.

Here we get the minimal archetype generating set of financial management of this college through the operational method of in-tree minimal archetype generating set.

$$A(t) = \{G_{12}, G_{13}, G_{17}, G_{23}, G_{27}, G_{36}, G_{37}, G_{47}, G_{157}, G_{257}, G_{357}\}$$

Classify by polarity: positive feedback archetype: $G_{12}, G_{13}, G_{17}, G_{23}, G_{36}$; negative feedback archetype: $G_{27}, G_{37}, G_{47}, G_{157}, G_{257}, G_{357}$.

Make classification by valuable significance: the number of students intensifies second-order positive feedback archetypes G_{12}, G_{13}, G_{17}; the number of teaching staff, fixed assets and fundraising intensify second-order positive feedback archetypes G_{23}, G_{36}, but restrict minimal archetypes $G_{27}, G_{37}, G_{47}, G_{157}, G_{257}, G_{357}$.

Then, archetypes with valuable significance are to be analyzed as follows:

Since colleges and universities run by non-governmental entities is considered as an act of profit earning, it is inevitable for them to have some common characteristics with enterprises [9]. These colleges and universities can be regarded as a sort of production plants, with new students as raw materials, undergraduates as processed products, graduates as finished products, teaching staff as manufacturers, and fixed assets (buildings, books, instruments, equipments etc.) as production facilities. Graduates who obtain employment can be taken as products sold out, otherwise, as inventory. Financial surplus indicates the viability of the "talents factory", while, employment rate shows the popularity of the "products". The regular operation of every single link is of vital importance to these colleges and universities.

Applying the formula in part *D*, take the coefficient of all positive feedback minimal archetypes as 1 and the coefficient of negative feedback minimal archetypes as 0, we can get G_{12367} by way of embedding operation. It indicates that the number of students, teaching staff, fixed assets input, the ability or amount of fundraising promote financial surplus. It also implies that the improvement of comprehensive quality is an important guarantee for the stable and healthy development of financial system, which tallies with the characteristics of pursuing both profit-making and public interest of privately-run colleges and universities [4]. Meanwhile, the undertaker is warned to make endeavor in enhancing the comprehensive quality rather than solely running after profit. Only if investors are able to balance the two factors between profit-making and public interest, can we reach a perfect state of both economic benefit and social effect.

Taking the coefficient of all negative feedback minimal archetypes as 1 and the coefficient of positive feedback minimal archetypes as 0, we can get G_{12367} by way of embedding operation. It indicates that expenses of students management, salary and welfare of teaching staff, input of fixed assets, enrollment expenses, expenses of consumable articles etc. restrict the status of financial surplus of school-running. It shows syntheses of maximum growth archetype. The leverage solution is to get rid of (or reduce) the source of limitation instead of pushing forward the "growth loop".

Hypothesize G_{17}, G_{47} coefficient is 1, and other minimal archetype coefficient is 0. We get negative feedback archetype G_{147} through doing embedding operation on minimal archetype focus elements. It reveals that the increase of enrollment expense brings about the increase of the number of students and then the increase of financial surplus. In this way, more money can be spent in enrollment, which forms a beneficial cycle. However, the enrollment expense itself directly restricts the growth of financial surplus. Reducing enrollment expense per student, i.e. damping the restrict source to advance the utilization efficiency of enrollment expense, is considered as the leverage solution of the archetype.

Privately-run colleges and universities in China have experienced a short history with imperfect management method [10]. Almost all these colleges and universities have faced the problem of being lack of capital [11]. The characteristic of income against expenditure is quite obvious. It is of their common concern to maintain a certain scale of school-running [12]. Like other counterparts of similar educational level, the most direct and efficient approach to attract enough students is to improve teaching quality, build fine reputation and make appropriate propaganda. Interviews on some experts show that all the mentioned colleges and universities adopt one way or another to encourage teaching staff to increase the number of new students, such as enrollment rewards (constitute an important part of enrollment expenditure). Some colleges and universities try to attract new students holding high score through bonus. All these phenomena reflect that privately-run colleges and universities are eager to reach the target of improving teaching quality and cultivating outstanding talents, which is the advantage of such private feature [13]. Indeed, it is natural to spend reasonable enrollment expenditure. However, the specific amount should be decided by comparison between marginal cost and marginal utility [14].

The above content is qualitative analysis. Quantitative analysis of higher requirements can be made through the method of vertex weighted feedback causal analysis in system dynamics, which is omitted here.

4 Conclusion

This thesis makes use of the method of setting minimal archetype generating set of complex system of system dynamics in the field of financial management. It shows a new way of analyzing for target optimization of high-order, non-linear and complex financial management system. This method can be used either to make comprehensive analysis of a whole system or transparentize and clarify existed problems in and among different parts of a system, cause of the problem, ways to influence system effect. And finally, it can be used to put forward comments and proposals for the improvement of system performance. This thesis has proved the effectiveness of this analyzing method through instances.

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On the China Resource Tax Policies of Exhaustible Resources in the Inter-temporal Dynamic Optimization—Coal Industry as an Example

Zhen-yu Guo and Xiao-ping Wei

Abstract The optimal application of exhaustible resources is the kernel scientific problem in normative theory, and it is key to dynamic optimization in an intergenerational framework. In this paper, a dynamic optimization mining model, which was developed by introducing the resource tax as a key variable, by making a distinction between the situation of price exogenous (perfect competitive market) and situation of price endogenous (inperfect competitive market), and by contrasting profit-based resource tax, quantity-based resource tax and price-based resource tax, was applied in studying how will the resource tax system arrangement impacts the exploitation path, price path and inter-temporal allocation of the exhaustible resources. Then, policy suggestions were given for the resource tax reform of China's coal industry.

Keywords Dynamic optimization • Exhaustible resources • Inter-temporal allocation • Resource tax

1 Introduction

Exhaustible resources, originated from the long-term geological age of nature, are regenerated in a low speed. Actually for human being, they are created by nature for only once. It is of great responsibility for policy regulation to allocate exhaustible resources in an inter-temporal framework and realize inter-temporal dynamic optimization. Resource tax, as development approach of government regulation, establishes practical basis for the study of exhaustible resources in the inter-temporal optimization.

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Nowadays resource tax reform in China is speeding up. Therefore, changes of tax revenue collection and tax rate would lay great effect on development and application of exhaustible resources. In 2007 China has up-regulated the tax rates of some mining resources, which marks the beginning of resource tax reform. In 2010, resource tax reform was performed in Xinjiang province. Resource tax of crude oil and gas was based on price rather than quantity and tax rate has changed into 5 %. In October 2011, the revised provisional regulations of resource tax in PRC by state council was implemented, in which tax rate of crude oil and natural gas was 5–10 % of sales volume by average, but coal tax was collected on quantity. In December 2011, state council printed and distributed the comprehensive working plan of resources-saving and energy reduction in the 12th Five-Year Plan. The financial policies of resources-saving and energy reduction should be made and the resource tax reform should be promoted. In April 2012, Inner Mongolia and Xinjiang province reported on the application on the pilot reform of coal resource tax which suggested that coal resource tax reform be promoted by collecting price-based tax.

Resource tax reform in China, obviously, is in a critical changing period, in which a new-around resource tax reform in western provinces has been under way and speeding up, with tax collection changed from quantity-based to price-based and tax rate raised. It is crucial for resource tax reform to take a scientific option of tax collection and rate and realize the optimal application of exhaustible resources.

2 Literature Review

At present studies on resource tax policies focus on how to evaluate the influence of specific taxes on resource exploitation path and resource allocation. Hotelling (1931) defines the exhaustible resources exploitation path and analyzes the influence of resource tax [1]. Conrad and Hool (1984) discuss on the influence of mining tax, price tax and progressive profit tax on resource margin grade and exploitation path [2]. Gamponia and Mendelsohn (1985) contrast the different effects of unit price, production price, property price and profit price on the efficiency of resource allocation based on data application, and analyze the influence of varieties of taxes on manufacture and consumer remainders [3]. Slade (1984, 1986) discusses the influence of tax collection on resource exploitation based on theory and practice [4, 5]. He holds that only through processing can resources be put into market. Therefore, he discusses on the influence of resource tax on resource exploitation on the basis of resource tax on each stage of resource processing. Rowse (1997) tests the social welfare losses by resource tax with a simulation model and analyzes the influence of price tax on inter-temporal allocation of natural gas [6].

The resource tax optimization should be designed in a given market that could lay a direct effect on the policy-making of governments and enterprises. Based on the study of resource optimizing mining against an inperfect competitive, Khalatbari (1977) points out that over-mining of "public land" is due to an obscure definition of property rather than inperfect competitive [7]. Furthermore, he advises on the optimal resource tax polices of "public land". Jeong-Bin Im (2002) considers that resource allocation can be effective in a perfect competitive market so that optimization of different resource tax can be discussed to make an effective resource allocation of monopoly market [8]. Ge Shi-long and Zhou De-qun (2009) discuss on the influence of resource tax expectation on mining on the condition of perfect competitive market [9]. Ge Shi-long, Zhou De-qun and Zhou Ming (2010) bring the discussion into varies uncertainty including technological uncertainty and different kind of market [10].

Under the deficiency of inter-temporal optimization of resources in an intergenerational framework, this paper introduces an inter-temporal dynamic optimization model of exhaustible resources with resource tax as a key variable. It works out the optimal exploitation path and price path of exhaustible resources and discusses on the influence of resource tax collection and tax rate on the paths, against both a perfect competitive market and an inperfect competitive market.

3 Optimal Mining Model of Exhaustible Resources

3.1 Variables Description

Variables which will be used in the optimal mining model of exhaustible resources are showed in the following table (see Table 1).

Table 1 Variable descriptions

Variable	Meaning	Variable	Variable
t	Current time	λ_t	User's costs in t (shadow price)
T	Time of resource exhaustion	r	Discount rate
S_t	Reserves of exhaustible resources in t	ϕ	Stoping rate
A	Original reserves of exhaustible resources	α	Profit-based tax rate
B	Final reserves of exhaustible resources	β	Quantity-based tax rate
C_t	Mining cost of resources in t	γ	Price-based tax rate
X_t	Produced reserves in t	H_c	Current-value Hamiltonian
Q_t	Volume (production and sales) in t	e^{-rt}	Discount factor
P_t	Resource price in t	X_t^*	Optimal exploitation path
$\overline{P}$	Upper limit of market price	$\frac{\dot{P}_t}{P_t}$	Optimal price path

3.2 Constraints and Assumptions

Assumption 1: assumption of perfect competitive and inperfect competitive. The resource prices in a perfect competitive market have nothing to do with individual enterprise produced reserves so that enterprises could only accept them passively. Thanks to the large quantities of mining enterprises in our country and substitutability of resources in different areas, especially the limited effects of individual enterprise on the whole market, the assumption of the perfect competitive market is compatible with the practice in the initial period.

During the 12th five plan period, the mining enterprises in our country would focus on the company merger and restructuring. Under the construction of more and more giant mining groups, the assumption of the perfect competitive market in resources mining would change a lot. The analysis of an inperfect competitive market would be based on the change in the following parts.

Assumption 2: assumption of no reserve effect. Reserves given, after-mining reserves do not affect mining cost.

Assumption 3: assumption of cost function. Mining cost $C_t(X_t)$, weak convexity, in t is a function relating to X_t. Its Hessian matrix is positive semi definite matrix, whose master determinant elements $\frac{\partial C}{\partial X_t}, \frac{\partial^2 C}{\partial X^2{}_t}$ are nonnegative. According to these requirements, for further analysis, quadratic function—$C_t\,(X_t) = \frac{a}{2}X_t^2 + C$ was selected. Among them, a represent the sensitive degree of margin cost level to exploitation quantity and stoping rate.

Assumption 4: assumption of resources exhaustibility. The resource is defined as exhaustible resources if it meets the following conditions. (1) The reserves will declining constantly, no matter when the resource begins to use. (2) The resource reserve will never increase. (3) The declining rate of resource reserves is the monotone increasing function of resource consumption rate. (4) Once the resource's reserve becomes a negative number, there will be no use of the resources.

We denote the resource reserve at t moment by S_t, the exploitation period by $t \in [0,T]$, and we get initial value A and final value B of S_t. The exploitation quantity of t moment is denoted by X_t, and the stopping rate is 100 % if not stated, then $S_t' = -X_t$.

Basic constraint conditions could be got:

$$Under: \begin{cases} \dot{S} = -X_t \\ S_0 = A, S_T = \mathrm{B} = 0, S_t \geq 0 \end{cases}.$$

Assumption 5: Market clearing hypothesis. All the exploited resources entered the market, not to storage. All enterprises' supply is equal to the amount of consumer demand, that is $X_t = Q_t$.

3.3 Target Function

In a situation of given resource price, cost function and the above constraint conditions, we can assume that mine enterprise will choose a exploitation path that maximizing current value of profit. The target function is:

$$Max \int_0^T [P_t X_t - C_t (X_t)] e^{-rt} dt \tag{1}$$

Among them, $P_t X_t$ and $C_t(X_t)$ are denoted by income and cost of t moment, e^{-rt} is the current value coefficient.

3.4 Resource Tax Variables

There are three main forms of resource tax, profit-based resource tax, quantity-based resource tax and price-based resource tax. Assume that the rates are α, β, γ, respectively. Given the three main collection forms, the objective function of mining enterprises throughout the whole mining process are

$$\begin{gathered} Max \int_0^T [P_t X_t - C_t (X_t)] \cdot (1-\alpha) e^{-rt} dt, \\ Max \int_0^T [P_t X_t - C_t (X_t) - \beta X_t] e^{-rt} dt \quad \text{and} \\ Max \int_0^T [P_t X_t \cdot (1-\gamma) - C_t (X_t)] e^{-rt} dt. \end{gathered}$$

By combining optimization mining target function with basic restrictions, we get the optimization mining model. We will discuss the issue in different situations which the market is divided into perfect competitive market and inperfect competitive market, and which the resource tax is arranged in different forms.

4 The Optimal Exploitation Path and Price Path Without Resource Tax

4.1 In a Perfect Competitive Market

Perfect competitive market could lead the whole economy to general equilibrium in a series of idealized assumption conditions. It also could be used as a standard to judge the efficiency level of other kinds of market. So, perfect competitive market of

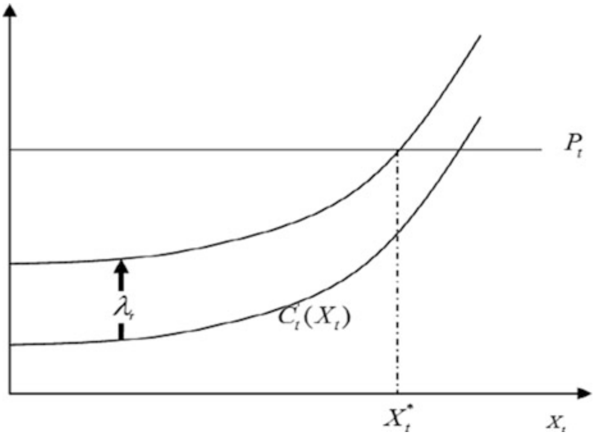

Fig. 1 Resource price and user cost

exhaustible resources could be used to compare and correct the imperfect efficiency of inperfect competitive market.

Target function and Constraint conditions:

$$Max\int_0^T [P_t X_t - C_t (X_t)]e^{-rt} dt \tag{2}$$

$$S.T. : \begin{cases} \dot{S} = -X_t \\ S_t \geq 0, S_0 = A, S_T = 0 \end{cases}$$

This model could be solved by using Current-value Hamiltonian—

$$H_c = P_t X_t - C_t (X_t) - \lambda_t X_t \tag{3}$$

and we get optimal path in the perfect competitive market without any resource tax.

$$\frac{\dot{P}_t}{P_t} = r\left[1\frac{C_t'(X_t)}{P_t}\right] \tag{4}$$

$$X_t^* = \frac{(1 - rTe^{rt})\, P_t}{1 + a + rTe^{rt}} + \frac{rS_0}{e^{rt} - 1} \cdot \frac{2e^{rt}}{1 + rTe^{rt}} \tag{5}$$

As in Fig. 1, users cost in t moment equals to the resource price deducts margin cost of exploitation. That is to say, resource price contains margin cost and users cost. The optimal holding rate X_t^* appears when the summation of margin cost $C_t^{'}(X_t)$ and uses cost λ_t equals to resource price P_t.

4.2 In an Imperfect Competitive Market

When certain degree of monopoly exists in a market, enterprises and society often tend to protect resource, which makes insufficient exploitation. At this moment, the resource price is in charge of the monopolist, and relevant to the exploitation quantity. Thus the enterprise profit function can be rewritten as follows.

$$\pi_t = P_t\left(X_t\right) X_t - C_t\left(X_t\right) \tag{6}$$

Thereinto, $P_t(X_t)$ is the resource price in a inperfect competitive market at t moment, and the price is affected by the exploitation quantity.

Then, the optimization mining model in the inperfect competitive market without resource tax is constructed.

$$Max \int_0^T \left[P_t\left(X_t\right) X_t - C_t\left(X_t\right)\right] e^{-rt} dt \tag{7}$$

$$S.T.: \begin{cases} \dot{S} = -X_t \\ S_t \geq 0, S_0 = A, S_T = 0 \end{cases}$$

By solving resource optimization mining model in this condition, the optimal price path is got.

$$\frac{\dot{P}_t}{P_t} = r\left[1 - \frac{C_t'\left(X_t\right)}{P_t\left(X_t\right)\left(1 + \frac{1}{\varepsilon}\right)}\right] \tag{8}$$

Thereinto, $\varepsilon = \frac{P_t(X_t)}{X_t P_t'(X_t)}$. And ε is demand elasticity coefficient, which is assumed to be negative constant. So, $1 - \frac{C_t'(X_t)}{P_t(X_t)\left(1+\frac{1}{\varepsilon}\right)} < 1$, which means the growth rate of price path in inperfect competitive market is lower than that in perfect competitive market.

Assumption 6: Assume the demand function has concavity, which means $\frac{dQ_t}{dP_t} < 0$. For convenience, a simplified linear form is chose, that is $Q_t = s\left(\overline{P} - P_t\right) = \overline{P} - P_t$. Thereinto, $\overline{P}$ is price cap. According to assumption of no reserve effect, we get $P_t = \overline{P} - X_t$. Then $Max\ W = \int_0^T \left[\left(\overline{P} - X_t\right) X_t - \frac{a}{2} X_t^2 - C\right] e^{-rt} dt$ is equivalent to, $Min\ J = \int_0^T \left[\left(1 + \frac{a}{2}\right) X_t^2 - \overline{P} X_t + C\right] e^{-rt} dt$.

After derivation, we can get optimal exploitation path in the inperfect competitive market without any resource tax.

$$X_t^* = \frac{\overline{P}\left(1 - rTe^{rt}\right)}{2 + a} + \frac{rS_0}{e^{rt} - 1} e^{rt} \tag{9}$$

5 The Optimal Exploitation Path and Price Path with Different Tax Arrangement

5.1 Profit-Based Resource Tax

The function of enterprises' profit with profit-based resource tax rate α is $\pi_t = [\mathrm{P_t}(X_t)X_t - C_t(X_t)](1-\alpha)$.

And the optimization model is shown as follows.

$$\begin{aligned} & Max\int_0^T (1-\alpha)\left[\mathrm{P_t}\left(X_t\right)X_t - C_t\left(X_t\right)\right]e^{-rt}dt \\ & S.T.:\begin{cases} \dot{S}_t = -X_t \\ S_t \geq 0, S_0 = A, S_T = 0 \end{cases} \end{aligned} \tag{10}$$

Because of $1-\alpha \geq 0$, the target function could be changed as follows.

$$Max\int_0^T \left[\mathrm{P_t}\left(X_t\right)X_t - C_t\left(X_t\right)\right]e^{-rt}dt$$

Obviously, given a profit-based resource tax does not change the optimization problem and (10) is equivalent to (7). Therefore, profit-based tax can only change mineral enterprise profit distribution, but not their mining behavior. Also don't affect the price path theoretically. From the perspective of resource tax function, the profit-based tax mode has poor adjustment function.

5.2 Quantity-Based Resource Tax

The function of enterprises' profit with quantity-based resource tax rate β is $\pi_t = \mathrm{P_t}(X_t)X_t - C_t(X_t) - \beta X_t$

And the optimization model is shown as follows.

$$\begin{aligned} & Max\int_0^T \left[P_t\left(X_t\right)X_t - C_t\left(X_t\right) - \beta X_t\right]e^{-rt}dt \\ & S.T.:\begin{cases} \dot{S}_t = -X_t \\ S_t \geq 0, S_0 = A, S_T = 0 \end{cases} \end{aligned} \tag{11}$$

Current-value Hamiltonian is constructed as follows.

$$H_c = P_t\left(X_t\right)X_t - C_t\left(X_t\right) - \beta X_t - \lambda X_t$$

The above function has the optimal solution of the extreme conditions for:

$$\dot{S}_t = \frac{\partial H_c}{\partial \lambda_t} = -X_t$$

$$\dot{\lambda}_t = r\left(\beta + \lambda_t\right)$$

$$\frac{\partial H_c}{\partial X_t} = P_t'\left(X_t\right)X_t + P_t\left(X_t\right) - C_t'\left(X_t\right) - \beta - \lambda_t = 0$$

$$\left[H_c\right]_{t=T} = 0$$

The derivation shows $\frac{\dot{\lambda}_t}{\lambda_t} = r\left(1 + \frac{\beta}{\lambda_t}\right)$, which means the change rate of resource shadow price has positive correlation with the quantity-based resource tax rate.

$$\lambda_t = P_t'\left(X_t\right)X_t + P_t\left(X_t\right) - C_t'\left(X_t\right) - \beta$$

After finishing, there are:

1. *The price path*

After derivation, we can get optimal price path in the inperfect competitive market with quantity-based resource tax.

$$\frac{\dot{P}_t}{P_t} = r\left[1 - \frac{C_t'\left(X_t\right) + \beta}{P_t\left(X_t\right)\left(1 + \frac{1}{\varepsilon}\right)}\right] \tag{12}$$

thereinto, $\varepsilon = \frac{P_t(X_t)}{X_t P_t'(X_t)} < 0$

2. *The exploitation path*

Considered the assumption of cost function (Assumption 3), the optimization model transformed as follows.

$Max\ W = \int_0^T \left[\left(\overline{P} - X_t - \beta\right)X_t - \frac{a}{2}X_t^2 - C\right]e^{-rt}dt$, which is equivalent to $Min\ J = \int_0^T \left[\left(1 + \frac{a}{2}\right)X_t^2 - \left(\overline{P} - \beta\right)X_t + c\right]e^{-rt}dt.$

After formula deformation, we get equation as follows.

$$Min\ J = \int_0^T \left(1 + \frac{a}{2}\right)e^{-rt}\left[X_t - \frac{\left(\overline{P} - \beta\right)}{2 + a}\right]^2 dt + \left[C - \frac{\left(\overline{P} - \beta\right)^2}{4 + 2a}\right]\frac{1 - e^{-rt}}{r}$$

Let $\left[C - \frac{\left(\overline{P}-\beta\right)^2}{4+2a}\right]\frac{1-e^{-rt}}{r} = \theta$, we get

$$MinJ = \int_0^T \left(1+\frac{a}{2}\right)e^{-rt}\left[X_t - \frac{\left(\overline{P}-\beta\right)}{2+a}\right]^2 dt + \theta.$$

Corresponding to the above optimization problem, Current-value Hamiltonian is constructed.

$H_c = \left(1+\frac{a}{2}\right)\left[X_t - \frac{\left(\overline{P}-\beta\right)}{2+a}\right]^2 - \lambda X_t$ Standard equation: $\dot{S}_t = -X_t$, $\dot{\lambda}_t = -\frac{\partial H_c}{\partial S_t} + r\lambda_t = r\lambda_t$

Extremum condition: $\frac{\partial H_c}{\partial X_t} = 2\left(1+\frac{a}{2}\right)\left[X_t - \frac{\left(\overline{P}-\beta\right)}{2+a}\right] - \lambda = 0$

Boundary condition: $\begin{cases} H_c(T) + \frac{\partial \theta}{\partial T} = 0 \\ S_0 = A, S_T = B = 0, S_t \geq 0 \end{cases}$

After derivation, we can get optimal exploitation path in the inperfect competitive market with quantity-based resource tax.

$$X_t = \frac{\left(\overline{P}-\beta\right)\left(1 - rTe^{rt}\right)}{2+a} + \frac{rS_0}{e^{rt}-1}e^{rt} \tag{13}$$

5.3 Price-Based Resource Tax

The function of enterprises' profit with price-based resource tax rate γ is $\pi_t = \mathrm{P}_t(X_t)X_t - C_t(X_t) - \gamma \mathrm{P}_t(X_t)X_t$, that is $\pi_t = (1-\gamma)\mathrm{P}_t(X_t)X_t - C_t(X_t)$.

And the optimization model is shown as follows.

$$\begin{aligned} &Max\int_0^T \left[(1-\gamma)\, P_t\left(X_t\right)X_t - C_t\left(X_t\right)\right]e^{-rt}dt \\ &S.T.: \begin{cases} \dot{S}_t = -X_t \\ S_t \geq 0, S_0 = A, S_T = 0 \end{cases} \end{aligned} \tag{14}$$

Current-value Hamiltonian is constructed as follows.

$$H_c = (1-\gamma)\, P_t\left(X_t\right)X_t - C_t\left(X_t\right) - \lambda X_t$$

The derivation shows $\frac{\dot{\lambda}_t}{\lambda_t} = r$, which means the change rate of resource shadow price has no correlation with the resource tax rate. Then we get the following equation.

1. *The price path*

After derivation, we can get optimal price path in the inperfect competitive market with price-based resource tax.

$$\frac{\dot{P}_t}{P_t} = r\left[1 - \frac{C_t'(X_t)}{P_t(X_t)(1-\gamma)\left[1+\frac{1}{\varepsilon}\right]}\right] \tag{15}$$

2. *The exploitation path*

For further analysis, we still use the assumption of the price and cost function of mining enterprise ($P_t(X_t)$, $C_t(X_t)$), and we get the profit function.

$$\pi_t = (1-\gamma)P_t X_t - C_t(X_t)$$

The optimization model is thus constructed as follows.

$$\begin{aligned} \max W &= \int_0^T [(1-\gamma)P_t X_t - C_t(X_t)]e^{-rt}dt \\ &= \int_0^T \left[(1-\gamma)\overline{P}X_t - \left(1-\gamma+\frac{a}{2}\right)X_t^2 - C\right]e^{-rt}dt \end{aligned}$$

$$S.T.: \begin{cases} \dot{S}_t = -X_t \\ S_t \ge 0, S_0 = A, S_T = 0 \end{cases}$$

After derivation, we can get the shadow price and optimal exploitation path in the inperfect competitive market with price-based resource tax.

$$\lambda_t = 2\left[1-\gamma+\frac{a}{2}\right]\left[X_t - \frac{(1-\gamma)\overline{P}}{2\left(1-\gamma+\frac{a}{2}\right)}\right]$$

$$X_t^* = \frac{(1-\gamma)\overline{P}}{2\left(1-\gamma+\frac{a}{2}\right)} + \frac{\lambda_t}{2\left(1-\gamma+\frac{a}{2}\right)} = \frac{(1-\gamma Te^{rt})\overline{P}}{2+\frac{a}{1-\gamma}} + \frac{rS_0}{e^{rt}-1} \tag{16}$$

6 Discussion

Based on the price path and exploitation path in the two kinds of markets, the results in the table can be explained as follows (see Table 2).

1. In a perfect competitive market, the price path of exhaustible resources is affected by marginal mining cost. As marginal mining cost is zero, the increasing rate

Table 2 List of price path and exploitation path of exhaustible resources

	Resource tax arrangement	The optimization model (omitting constraint conditions)	Price path	Exploitation path
Perfect competitive market	None	$Max \int_0^T [P_t X_t - C_t(X_t)]e^{-rt}dt$	$\frac{\dot{P}_t}{P_t} = r\left[1 - \frac{C_t'(X_t)}{P_t}\right]$	$X_t = \frac{(1-rTe^{rt})P_t}{1+a+rTe^{rt}} + \frac{rS_0}{e^{rt}-1} \cdot \frac{2e^{rt}}{1+rTe^{rt}}$
Inperfect competitive market	None	$Max \int_0^T [P_t(X_t)X_t - C_t(X_t)]e^{-rt}dt$	$\frac{\dot{P}_t}{P_t} = r\left[1 - \frac{C_t'(X_t)}{P_t(X_t)\left(1+\frac{1}{\varepsilon}\right)}\right]$	$X_t = \frac{\overline{P}(1-rTe^{rt})}{2+a} + \frac{rS_0}{e^{rt}-1}e^{rt}$
	Profit-based resource tax	$Max \int_0^T [P_t X_t - C_t(X_t)](1-\alpha)e^{-rt}dt$		
	Quantity-based resource tax	$Max \int_0^T [P_t(X_t)X_t - C_t(X_t) - \beta X_t]e^{-rt}dt$	$\frac{\dot{P}_t}{P_t} = r\left[1 - \frac{\beta + C_t'(X_t)}{P_t}\right]$	$X_t = \frac{(\overline{P}-\beta)(1-rTe^{rt})}{2+a} + \frac{rS_0}{e^{rt}-1}e^{rt}$
	Price-based resource tax	$Max \int_0^T [(1-\gamma)P_t(X_t)X_t - C_t(X_t)]e^{-rt}dt$	$\frac{\dot{P}_t}{P_t} = r\left[1 - \frac{C_t'(X_t)}{P_t(X_t)(1-\gamma)\left[1+\frac{1}{\varepsilon}\right]}\right]$	$X_t = \frac{(1-\gamma Te^{rt})\overline{P}}{2+\frac{a}{1-\gamma}} + \frac{rS_0}{e^{rt}-1}$

of resource price equals to discount rate, compatible with Hotelling law. As marginal mining cost is positive, the increasing rate of resource price is less than discount rate.

At the same time, the exploitation path of exhaustible resources is affected by different factors so that optimal mining reserves are related to service hours in mining area, market price level, positive correlation with original reserves, and negative correlation with cost level.

2. In an inperfect competitive market, without interventions of enterprises by governments, price path is negatively correlated with marginal cost and demand elasticity coefficient. While declining prices would reduce optimal mining reserves, even mining deficiency.

   On the other hand, exploitation path of exhaustible resources is positively correlated with market price level and original reserves, negatively correlated with discount rate, service life of mine and cost convexity.
3. In an inperfect competitive market, profit-based tax can only affect profit allocation in enterprises rather than adjust resources exploitation path and resource price path, in which optimal path is equivalent to no taxes in an inperfect competitive market.
4. In an inperfect competitive market, under the quantity-based resource tax system, increase of holding rate and decrease of quantity-based tax rate improve exploitation quantity, while increase of service life of mines and cost convexity reduce the exploitation quantity. Quantity-based resource tax becomes the additional part of marginal cost. Therefore with tax rate increasing, market price of resources improves as well, while growth rate of price decreases. Quantity-based resource tax lays a greater effect on exploitation quantity. With tax rate increasing, cost approaches upper limit of market price. As a result of supply–demand relationship, contribution margin of per unit resources declines and enterprises would reduce optimal exploitation quantity.
5. In an inperfect competitive market, with the price-based resource tax system, marginal cost and demand elasticity have the some effect on prices with quality-based resource system. Price-based resource tax rate is negatively correlated with price increase rate. Accordingly, with the increase of resource tax rate, optimal exploitation level drops, resource scarcity degree and the absolute level of market price improve. While the price increase rate decreases as well.

7 Conclusion

In accordance with the current situation of resource tax in China’s coal industry, this paper comes to the conclusion as follows:

1. Profit-based tax cannot replace resource tax.

   Price path and exploitation path of coal industry aren’t affected by profit-based tax so that single profit-based tax rate cannot regulate inter-temporal allocation of resources. Even if inter-temporal profit-based tax rate is not consistent, it cannot regulate resource mining activities. Due to the complex situations of listed companies in China's coal industry, related enterprises and enterprise-run society can not be regulated with an inter-temporal framework, which controls the enterprise in short term. Therefore, any tax collection behind "the windfall profit" of coal industry can only satisfy the revenue function of related sectors. While it doesn't involve operation and current situation of the whole industry and fulfill the function of resource tax related to resource protection and mining modification.

2. Price-based resource tax policy needs a dynamic adjustment combined with demand elasticity.

   Quantity-based resource tax is the addition to the coal marginal cost, negatively correlate with price path, while price-based resource tax is positively correlated with price path, while policy effect also affected by demand elasticity. When it reaches a high level, coal industry cannot transfer tax burden from price-based tax. So demand elasticity should be taken into consideration if the real resource price is adjusted by price-based resource tax. When it comes to a downturn of coal market and higher demand elasticity, tax rate should decrease to relieve the financial crisis of coal industry. On the contrary, when coal markets flourishes with a lower demand elasticity, tax rate should considerably increase which could make full use of coal resources through higher coal price passed on to consumers and supply–demand relationship controlling excessive consumption.

3. Price-based resource tax policy needs a dynamic adjustment combined with cost level of coal industry.

   Quantity-based resource tax is negatively correlated with exploitation path, compared with decreasing market price to control excessive exploitation. Price-based resource tax is negatively correlated with exploitation path as well, which should be assessed by mining cost level. Among those enterprises of China's coal industry, some new ones take a bigger part of variable cost with lower tax burden. They reduce production on a higher tax rate so as to optimize the overall profit within the mining period. On the other hand, with heavy historical and social burden, the older ones take a larger proportion of fixed cost. When market price decreases or tax rate increases, they have to make up their losses through additional production. This should be handled respectively according to China's coal market with saturation even surplus of productivity. With better mining conditions, higher quality and less historical burden, some newly-developed coal enterprises in western areas can be applied to higher price-based tax rate; while those in eastern areas can be applied to lower price-based tax rate.

To sum up, resource tax is a significant means of exhaustible resources mining regulation by governments, with its collection and rate laying direct effect on exploitation path and price path of mines. In this paper, a normative study is introduced on resource tax system reform with some theoretical references. Based on strict assumptions, the conclusion is still limited to some degree and needs further study with more assumptions.

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Study on Customer Value Driving Model of Network Marketing Environment

Ji-lin Wang

Abstract The research status of customer value in both foreign and domestic literatures is summarized, and the existing research deficiencies are pointed out. Combining the characteristics of network marketing, the customer deceived value models (theoretical and Amos) of network marketing environment are constructed, and the corresponding model hypotheses are put forward. Based on the spot-investigation, and using SPSS and structural equation model, the empirical research on customer value driving is conducted, which demonstrates the theoretical model is scientific and reasonable. The hypothesis test results of the model are put into in-depth discussion.

Keywords Customer value • Customer perceived value • Network marketing • SEM

1 Introduction

Along with the rapid development of contemporary marketing theory and the improvement in the field of network marketing, integrated marketing, relationship marketing, service marketing, green marketing innovation of marketing concepts, the marketing theory research and practice also continues to depth direction. Scholars try to elaborate how enterprises could build up their competitive advantage from value chain management, quality management, BPR, and enterprise culture aspects, but all these efforts are based on the fundamental organization and the internal improvement [1]. When these efforts can't take market as the guidance, enterprises' products and services cannot be accepted by customers, and it is difficult

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to establish the true competitive advantage. In seeking for new source of competitive advantage, people begin to look from the enterprise internal steering to external customers.

Customer is the starting point and the foothold of enterprise marketing activities. Only customer's needs are accurately identified and well satisfied, can the enterprise survive and gain sustainable development. Standing on the customer's point of view, enterprises should really understand what customer value consumers want to obtain from the experience of purchase, and effectively transfer customer value, to achieve long-term customer satisfaction and customer loyalty.

Meanwhile, based on the modern technology of communication and internet application, network marketing will surely become a trend and the mainstream in the twenty-first century marketing, and the research on customer value and driving factors of network marketing environment will also be a new field of theoretical study [2]. Research on customer value drivers of network marketing environment is of important theoretical and practical significance for enriching and developing related theories of the field.

2 Customer Value Research and Deficiency

Early in the 1980s, Drucker proposed: "the real meaning of marketing lies in understanding what is valuable for customers." After this, especially in the late 1980s and early 1990s, along with the increasing competition, more and more enterprises shifted perspective to customer value.

Customer value related research has aroused the interest of many scholars, but the research of this field is still at the primary stage. Scholars even hold different opinions on what customer value research should contain. Comprehensively analyzing and comparing the achievement of customer value research, some typical and representative customer value definitions of foreign scholars are shown below (Table 1):

Table 1 Typical and representative customer value definitions

Scholar	Definition of customer value
Zeithaml (1998)	Value is the overall appraisal on product utility, based on consumers' perception of what they gain and lose [3].
Anderson et al. (1993)	The buyer's value perception depends on the measurement of gain (quality perception) against loss (price perception) [4].
Gale (1994)	In organizational markets, value is the acquirer enterprises' perception of a particular product for its premium gained in economy, technology, service and social benefit [5].
Butz et al. (1996)	Customer value is the emotional tie built between the customer and supplier [6].
Woodruff (1997)	Customer value is the perception preferences and evaluation of customers for some properties and performance of product in certain situations [7].

Table 2 Abroad theoretical models of customer value

Scholar	Name of theoretical model	Study perspectives
Kotler [8]	Customer delivered value	From customer delivered value and customer two perspectives
Jeanke, Ron [9]	Customer value	From the supplier and the customer two perspectives
Woodruff [10]	Customer value hierarchy	From customer perception value offered by enterprises
Weingand [11]	Customer hierarchy	Customers are divided into four different levels
Woodruff [7]	Time change model	Change of using situation will cause change of customer value perception

Based on the research of customer value, series of theoretical models are put forward by foreign scholars. Listed in Table 2:

Numerous domestic scholars also did a lot of researches on customer value from different aspects, and some customer value related theoretical models are put forward, such as customer value supply and demand model, customer value house model, customer lifetime value model, etc.

Although scholars have done a lot of research on customer value and its related fields, there are still some deficiencies and new fields for further study. The relationship between customer value and related concepts need to be further studied, such as customer value, customer loyalty and customer satisfaction. The potential value of customer is ignored in existing customer value researches. With the rapid development of information technology, the change of customer behavior and customer value need to be furthered studied. Along with the advance of economic globalization and global market, customer value perception in different cultural background need to further researched. From the time dimension, the dynamic customer value need to be further discussed, while not only confined to the dynamic customer expectation research. In theory applications, theoretical researches need to be combined with enterprise practice.

3 Customer Value Driving Model and Research Hypotheses

A trigger event model of customer value change is put forward by Woodruff etc, which considers that the dynamic characteristics of customer value are caused by driving factors. The value concept is distinguished by value, customer desired value, and value judgment. Different driving factor leads to different value concept change, which causes the change of customer satisfaction and customer loyalty. Sheth, Newman and Gross (1991) describe five kinds of driving factors of value choice: functional value, social value, emotional value, environment value and conditional value [12]. Parasuraman (1997) put forward the service, price and quality are the three main customer value driving factors [13]. Keith A. Richards, Eli Jones (2008) describes the driving effect of product, price, channel, brand and service on the

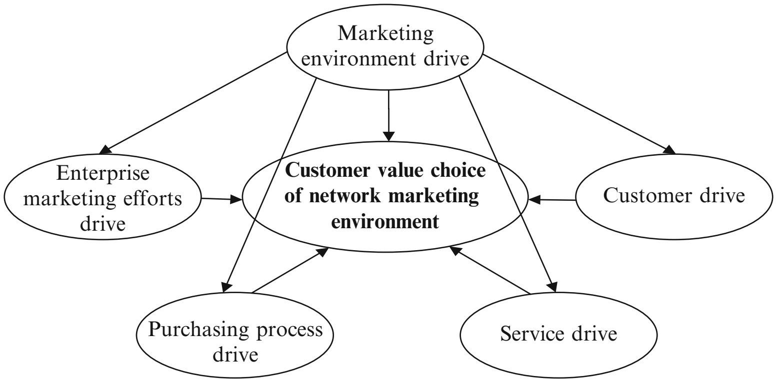

Fig. 1 Customer value driving model of network marketing environment

Table 3 Reach hypotheses

No.	Hypotheses
H1	Marketing environment drive has certain effect on customer value choice
H2	Marketing environment drive has certain effect on enterprise marketing efforts drive
H3	Marketing environment drive has certain effect on customer characteristic drive
H4	Marketing environment drive has certain effect on purchasing process drive
H5	Marketing environment drive has certain effect on service drive
H6	Enterprise marketing efforts drive has certain effect on customer value choice
H7	Customer characteristic drive has certain effect on customer value choice
H8	Purchasing process has certain effect on customer value choice
H9	Service has certain effect on customer value choice

customer value, and proposes to enhance customer relationship management from the perspective of customer value driven strategy [14].

Based on the relevant research of customer value at home and abroad, combining network marketing its own characteristics, the customer value driving model of network marketing environment is constructed (Fig. 1).

According to the above model, hypotheses from H1 to H9 are proposed as listed in Table 3.

4 Empirical Study

The questionnaire is designed by Richter 7 points scale, and a questionnaire survey was conducted in 500 samples by random sampling. By using SPSS and AMOS analysis software, statistical analysis is conducted as follows.

Table 4 Variable set

Latent variables	Observation variables
Customer value choice of network marketing environment (η)	
Enterprise marketing efforts drive (ξ1)	Product drive (X11), Price drive (X12), Place drive (X13), Promotion drive (X14)
Marketing environment drive (ξ2)	Economic drive (X21), Political and legal drive (X22), Technical drive (X23), Societal drive (X24)
Customer drive (ξ3)	Economical drive (X31), Life style drive (X32), Cultural drive (X33)
Purchasing process drive (ξ4)	Demand drive (X41), Decision-making drive (X42), Post-purchase evaluation drive (X43)
Service drive (ξ5)	Supplier service drive (X51), on-line payment drive (X52), Delivery service drive (X53)

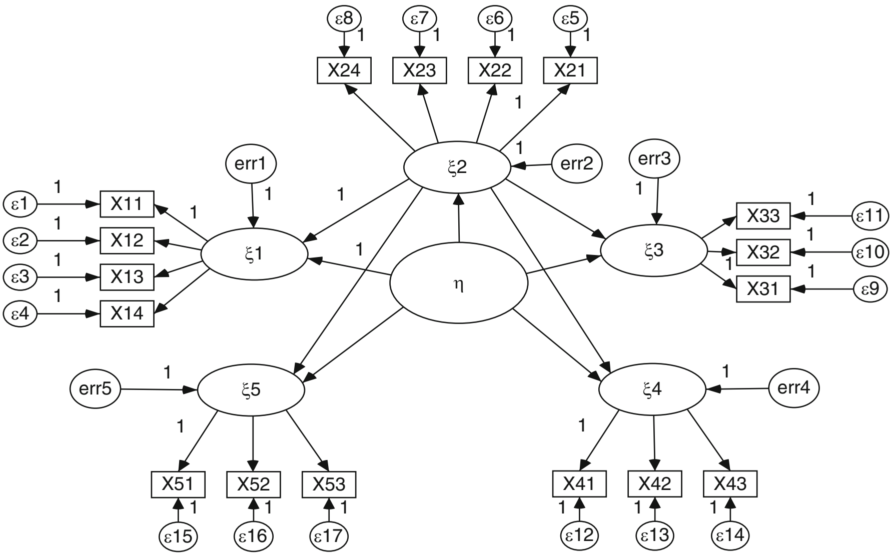

Fig. 2 Structural equation model based on AMOS

4.1 Structural Equation Modeling

Latent variables are set based on the structural equation model. The observation variables and latent variables are shown in Table 4.

According to the relationship between latent variables and measurable variables, structure model based on AMOS is established as Fig. 2.

Table 5 Reliability test

Reliability statistics	
Cronbach's Alpha	No of items
.894	17

Table 6 KMO and Bartlett test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.825
Bartlett's Test of Sphericity	Approx. Chi-Square	716.969
	df	136
	Sig.	.000

4.2 Reliability and Validity Test

The reliability test is conducted by Cronbach's Alpha. According to the revised questionnaire as measured, the value of Cronbach's Alpha is 0.894 as shown in Table 5. The reliability is high.

Based on the exploratory factor analysis, the validity of samples is confirmed by KMO and Bartlett's test, shown in Table 6.

4.3 Model Estimation and Evaluation

Based on the result of confirmatory factor analysis, the measurement model and structural model is deeply discussed. The structural model statistical results are shown in Fig. 3.

The corresponding P values of path coefficients between latent variables were less than 0.01, indicating the relationship between the hypotheses of the latent variable is significant. The fit index of the structure model is shown in Table 7. As a whole, the structure model is good fitting.

5 Conclusions

General conclusion could be summarized as follows: Marketing environment drive has direct and negative effect on customer value choice of network marketing; Marketing environment drive has significant impact on enterprise marketing efforts drive, consumer drive, purchasing process drive and service drive; The enterprise marketing efforts have significant effect on customer value choice of network marketing environment; Consumer drive has significant effect on customer value choice of network marketing environment; Purchase process drive has significant effect on

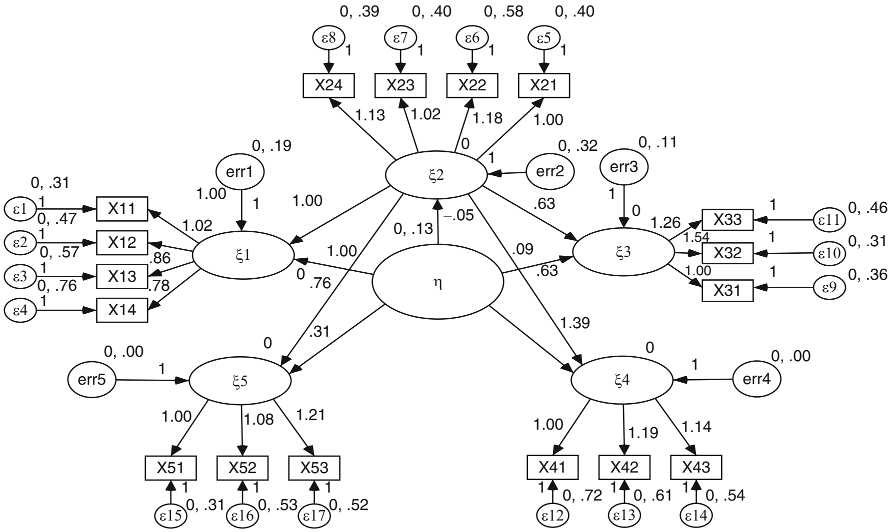

Fig. 3 Structural model statistical results

Table 7 Fit index of the structure model

Index		Value	Explanation
Absolute fit index	χ^2	212.537	$\chi^2/\mathrm{df} = 1.915 < 3$, acceptable
	df	111	
	RMSEA	0.067	<0.1, acceptable
	GFI	0.896	>0.8, acceptable
Comparative fit index	NFI	0.908	>0.9, acceptable
	TLI	0.877	>0.8, acceptable
	CFI	0.838	>0.8, acceptable

customer value choice of network marketing environment; Service drive has significant effect on customer value choice of network marketing environment; Online shopping consumers show common characteristics of young, price sensitive etc.

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Research on Technological Innovation Efficiency of China's High-Tech Industry Based on Network SBM Model and DEA Window Analysis

Jian-li Chen and Ling-jie Meng

Abstract The paper combines network SBM model with DEA window analysis to measure the technological innovation efficiency of China's high-tech industry during 2000–2011. The research indicates that the overall efficiency of technological innovation of the high-tech industry shows a rising trend in the past 10 years, and the outbreak of the financial crisis has a negative impact on the efficiency of technological innovation in the short term. The efficiency values of technological innovation are still not high, and there is structural imbalance between R&D efficiency and conversion efficiency in the long term. The difference of the conversion efficiency among the industry segments shows trend of convergence, but the difference of R&D efficiency expands after the financial crisis.

Keywords DEA window analysis • High-tech industry • Network SBM model • Technological innovation efficiency

1 Introduction

The high-tech industry is a strategic leading industry in China, which has experienced rapid development in the past 10 years. The international financial crisis which broke out in 2008 once brought significant impact to the development

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of China's high-tech industry because of its high degree of internationalization. Therefore, it is of great significance for deepening the study of technological innovation efficiency by using advanced models and tools to measure the time trend and industrial difference in China's high-tech industry, especially reveal the impact of financial crisis on efficiency change.

In recent years, DEA method, particularly network DEA method becomes an important method at the forefront of the research of technological innovation efficiency. Using network DEA method, the technological innovation process can be decomposed to technological R&D process and technological conversion process, therefore it overcomes the shortcoming of the traditional DEA method which ignores internal production structure and thus cannot effectively estimate the real input-output efficiency. The easiest form of network DEA model is two-stage DEA model proposed by Sexton and Lewis (2003) [1], which treated technological R&D process and technological conversion process as independent units. Xiao, Feng and Han (2012) [2], Yu (2009) [3], Liu and Chen (2011) [4] all have used this method to study the two stage efficiencies of China's high-tech industry. The two-stage DEA model does not consider the correlation between the stages, and cannot estimate the overall efficiency in a unified framework. In recent years, the relational network DEA models have been gradually applied in evaluating the technological innovation efficiency in China's high-tech industry. Chen, Feng, Jiang and Kang (2010) [5], Qian, Chen and Xiao (2012) [6] all used chain relational network DEA model to evaluate the overall efficiency and divisional efficiency of China's regional innovation of the high-tech industry. Yin (2012) [7] utilized network SBM model to measure efficiency of regional innovation in China. Feng, Ma and Zhang (2011) [8] evaluated the industrial innovation efficiency of high-tech industry by using chain network DEA model.

Currently, scholars mostly use cross-sectional data to estimate the technological innovation efficiency of China's high-tech industry by using network DEA model, their research results are thus confined in the latest technological innovation period. This paper attempts to combine network SBM model with DEA window analysis to measure the dynamic trend of the technological innovation efficiency based on the panel data of China's high-tech industry during 2000–2011.

2 Methodology

2.1 Research Methods

There are various forms of DEA model from different perspectives [9–12]. Network SBM model proposed by Tone and Tsutsui (2009) [13] cannot only estimate the overall efficiency of a network DMU, but also decompose the overall efficiency into divisional efficiencies. It is a non-radial DEA model, and can set the right weight based on the importance of various divisions.

This paper utilizes the input-oriented SBM model under the assumption of variable returns-to-scale (VRS) and free link case. Consider a system of two processes. Let $x_{ij}^{k}(i=1,2,\ldots,m_k)$ and $y_{rj}^{k}(r=1,2,\ldots,r_k)$ be defined as the inputs and outputs to $DMU_j(j=1,2,\ldots,n)$ at process $k(k=1,2)$. Denote $z_{dj}(d=1,2,\ldots,t)$ as the linking intermediate product from process 1 to process 2. The overall efficiency of DMU_0 is calculated by the following model:

$$\rho_0^* = \min_{\lambda^k, s^{k-}} \sum_{k=1}^{2} w^k \left[1 - \frac{1}{m_k}\left(\sum_{i=1}^{m_k} \frac{s_i^{k-}}{x_{i0}^k}\right)\right]$$

$$s,t.x_{i0}^k = \sum_{j=1}^{n} x_{ij}^k \lambda_j^k + s_i^{k-} \ (i = 1,2,\ldots,m_k)$$

$$y_{r0}^k = \sum_{j=1}^{n} y_{rj}^k \lambda_j^k - s_r^{k+} \ (r = 1,2,\ldots,r_k)$$

$$\sum_{j=1}^{n} \lambda_j^k = 1$$

$$\sum_{j=1}^{n} z_{dj} \lambda_j^1 = \sum_{j=1}^{n} z_{dj} \lambda_j^2, (d = 1,2,\ldots,t)$$

$$\lambda_j^k \geq 0, s_i^{k-} \geq 0, s_r^{k+} \geq 0, w_k \geq 0, \sum_{k=1}^{2} w_k = 1, \forall k = 1,2$$

Where ρ_0^* denotes the overall efficiency of DMU_0; s_i^{k-} and s_r^{k+} are input and output slacks of process k. w_k is the relative weight of process k. We put $w_1 = w_2 = 0.5$ in this article.

Let $\lambda_j^{k*}, s_i^{k-*}, s_r^{k+*}$ denote the optimal solution solved form the above model. Then the overall efficiency and the efficiency of process k can be calculated as:

$$\rho_0^* = \sum_{k=1}^{2} w_k \left[1 - \frac{1}{m_k}\left(\sum_{i=1}^{m_k} \frac{s_i^{k-*}}{x_{i0}^k}\right)\right]$$

$$\rho_k^* = 1 - \frac{1}{m_k}\left(\sum_{i=1}^{m_k} \frac{s_i^{k-*}}{x_{i0}^k}\right), \quad k = 1,2$$

Network SBM model can only analyze cross-sectional data, which means that the role of the time cannot be considered. In this paper, we use panel data of China's high-tech industry from 2000 to 2011, and try to combine network SBM model and DEA window analysis proposed by G. Klopp (1985) [14] to estimate the efficiency. In other words, we use network SBM model to estimate all DMU's efficiencies in each window. DEA window analysis treats the DMUs of different time as different DMU, and selects a different reference set to evaluate the relative efficiency of a DMU by using the method similar to the moving average [15]. Therefore, the efficiency values evaluated by this method cannot only reflect the heterogeneity between each DMU, but also reflect the changes of each DMU's efficiency [16].

2.2 Input/Output Indicator Selection

The process of technological innovation has apparent characteristics of two-stage. The first stage is the process of the technology research and development. In this stage, R&D departments product patents, papers, monographs and the others outputs with the R&D investments. The second stage is the conversion of the technological achievements, which includes the industrialization of domestic technological innovations and the foreign technology from acquisition. The above structure of the technological innovation is a simplified form of the network structure.

We choose intramural expenditure on R&D and full-time equivalent of R&D personnel as the inputs of technology R&D stage, and the number of patent applications as the output. Considering the impact of R&D activities on the production of knowledge is a continuous process, we utilize R&D capital stock which is calculated by using the perpetual inventory method instead of using the intramural expenditure on R&D directly. The intramural expenditure on R&D should be deflated by the R&D price index [4] before calculating R&D capital stock, in which the R&D price index = 75 %*PPI + 25 %*CPI.

The inputs of the technological conversion process include the output of the first stage, number of patents in force, expenditure on new products development, expenditure on technology acquisition and reconstruction, and annual average number of employed personnel. We choose output value of new products, the sale rate of new products (sales revenue of new products/output value of new products), the export rate of new products (export sales revenue of new products/sales revenue of new products) as the outputs. In addition, the output value of new products should be deflated in order to eliminate the impact of price change. Industries in Manufacture of Medicines are deflated by PPI of the chemical industry and the other industries are deflated by PPI of the mechanical industry.

3 Empirical Results and Analysis

3.1 The Sample and Data

The sample of this study is the industry segments of China's high-tech industry, including Manufacture of Chemical Medicine (H1), Manufacture of Finished

Traditional Chinese Herbal Medicine (H2), Manufacture of Biological and Biochemical Chemical Products (H3), Manufacture and Repairing of Airplanes (H4), Manufacture of Spacecrafts (H5), Manufacture of Communication Equipment (H6), Manufacture of Radar and Its Fittings (H7), Manufacture of Broadcasting and TV Equipment (H8), Manufacture of Electronic Appliances (H9), Manufacture of Electronic Components (H10), Manufacture of Domestic TV Set and Radio Receiver (H11), Manufacture of Other Electronic Equipment (H12), Manufacture of Entired Computer (H13), Manufacture of Computer Peripheral Equipment (H14), Manufacture of Office Equipment (H15), Manufacture of Medical Equipment and Appliances (H16), Manufacture of Measuring Instrument (H17). The time period is from 2000 to 2011. Data for input and output are extracted from China Statistics Yearbook On High Technology Industry, and the other data are extracted from Wind Information. Considering the time delay between input and output, this study set a time lag of 1 year on input and output. Therefore, the input data of the technological R&D process are from 2000 to 2009,the output data of it are from 2001 to 2010,and the input data of the technological conversion process are from 2001 to 2010,the output of it are data from 2002 to 2011.

3.2 Results and Discussion

In this section, we apply the proposed method to estimate the overall efficiency, R&D efficiency and conversion efficiency of the 17 industry segments. The width of the window is set to be four. Calculation of the model is done through software DEA-Solver8.0.

We calculated the average efficiency of 17 industry segments in every year. Results presented in Fig. 1 show that the overall efficiency, the R&D efficiency and the conversion efficiency of china's high-tech industry all show a rising trend in the past 10 years, and the conversion efficiency is significantly higher than the R&D efficiency. The values of the three types of efficiency are all not high. Although the overall efficiency grows with an average annual rate of 4.42 %, its mean value is still lower than 0.5. The values of R&D efficiency are in the low growth range of 0.25–0.31. Therefore, the conversion efficiency has been the main driving force of the technological innovation efficiency of China's high-tech industry. Although the overall efficiency is in the rise, but there is a serious imbalance between R&D efficiency and conversion efficiency, which reveal that most of the high-tech industries in china have paid more attention to the conversion and application of technology than the technological R&D.

Since 2008, the conversion of the economic cycle and the impact of the financial crisis have brought significant influence on the efficiency change of technological innovation of China's high-tech industry. The biggest decline took place in 2009 from the perspective of efficiency trend. The overall efficiency fell 10.46 %, and R&D efficiency fell 13.97 % in 2009. But then, three types of efficiency values quickly rebounded, and the overall efficiency and the conversion efficiency reached

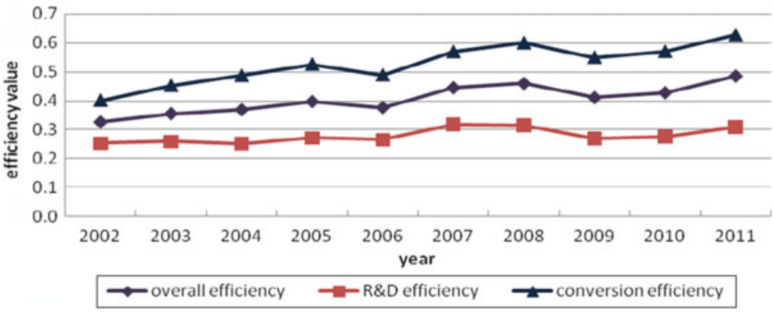

Fig. 1 Mean values of technological innovation efficiency for the 17 industry segments, 2002–2011

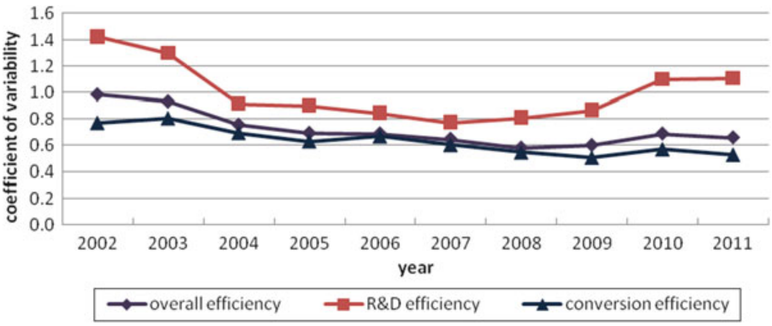

Fig. 2 The CV of technological innovation efficiency for the 17 industry segments, 2002–2011

a record high value. In practice, China's high-tech industries have showed the ability to return to growth and ability to withstand the crisis in the whole manufacturing industry. The financial crisis prompted more high-tech companies that rely on low-cost to pay more importance on technological innovation with upgrading the technological level and improving the efficiency of R&D and technological conversion.

We also calculate the coefficient of variability (CV) of efficiencies of 17 industry segments in every year. Results presented in Fig. 2 show that the CV of the overall efficiency and the conversion efficiency are both shrinking continually, but the CV of the R&D efficiency is increasing after 2007. These means that the difference of the degree of emphasis on R&D and independent innovation in China's high-tech industry is becoming bigger and bigger. It is no doubt that the comparative advantage in R&D efficiency will be helpful to the industry transformation and upgrading.

In order to thoroughly examine the impact of the financial crisis on the efficiency of technological innovation of China's high-tech industry, we calculate the average efficiency of 17 industry segments in three certain time intervals, that is interval I (2002–2011), interval II (2006–2008) and interval III (2009–2011). As can be seen

Table 1 Average efficiencies of 17 industry segments of Chinese high-tech industry in three intervals

	Interval I			Interval II			Interval III		
Industry	ρ_0^*	ρ_1^*	ρ_2^*	ρ_0^*	ρ_1^*	ρ_2^*	ρ_0^*	ρ_1^*	ρ_2^*
H1	0.104	0.049	0.158	0.102	0.055	0.148	0.144	0.070	0.217
H2	0.121	0.083	0.159	0.124	0.091	0.156	0.162	0.095	0.229
H3	0.331	0.228	0.434	0.364	0.282	0.447	0.403	0.243	0.563
H4	0.123	0.035	0.212	0.128	0.038	0.217	0.125	0.049	0.201
H5	0.560	0.303	0.817	0.649	0.361	0.937	0.555	0.214	0.896
H6	0.617	0.495	0.739	0.635	0.536	0.735	0.915	0.847	0.984
H7	0.547	0.345	0.748	0.685	0.437	0.933	0.585	0.361	0.808
H8	0.815	0.739	0.891	0.710	0.622	0.798	0.857	0.773	0.940
H9	0.174	0.081	0.267	0.168	0.088	0.248	0.188	0.080	0.297
H10	0.122	0.067	0.177	0.119	0.075	0.162	0.171	0.082	0.260
H11	0.397	0.238	0.556	0.373	0.220	0.527	0.299	0.124	0.474
H12	0.432	0.316	0.548	0.569	0.470	0.668	0.393	0.285	0.501
H13	0.624	0.371	0.877	0.620	0.297	0.943	0.586	0.336	0.836
H14	0.668	0.423	0.913	0.685	0.436	0.916	0.534	0.156	0.761
H15	0.795	0.680	0.911	0.750	0.648	0.851	0.817	0.706	0.928
H16	0.353	0.295	0.411	0.416	0.347	0.485	0.341	0.221	0.461
H17	0.158	0.081	0.234	0.161	0.095	0.228	0.214	0.101	0.326
Mean	0.408	0.284	0.532	0.427	0.300	0.553	0.429	0.279	0.570

Notes: ρ_0^* is overall efficiency; ρ_1^* is R&D efficiency; ρ_2^* is conversion efficiency

in Table 1, the average values of the overall efficiency and conversion efficiency in interval III are higher than those in interval I and interval II, but it not right to the R&D efficiency. This shows that the occurrence of the international financial crisis makes Chinese high technology enterprises pay more attention to the promotion of the conversion efficiency than the R&D efficiency which reflect the industry's core competitiveness. In fact, the expenditure for technical renovation and acquisition of foreign technology are significantly greater than the expenditure for assimilation of technology in China's high-tech industry for a long time. Most of the high-tech enterprises are keen on following foreign technology and expanding the production capacity at the low end of the value chain, which greatly inhibits the ability of independent innovation.

Conversion efficiency of all industries is higher than the R&D efficiency within the three intervals, which further indicates that the level of the two types of efficiency of China's high-tech industry is unbalanced. In the market-oriented and competitive environment, conversion efficiency tends to be slightly higher than R&D efficiency, which is reasonable normally. However, there may be problems in the development and transformation of the industry with the continuation of this situation. The prevalence of this problem also reflects the tendency of pragmatism in many high-tech industries, as well as the disjunction between the technological R&D and conversion. With the change of the international division of labor after the outbreak of financial crisis, lack of capability and efficiency for independent innovation will have a negative influence on international competitiveness and industrial upgrading of China's high-tech industry.

As can be seen from Table 1, both in the pre-crisis and post-crisis, the two types of efficiency values of Manufacture of Communication Equipment (H6), Manufacture of Broadcasting and TV Equipment (H8), Manufacture of Office Equipment (H15) have remained the leading. However, the two types of efficiency values are relatively lower in Manufacture of Chemical Medicine (H1), Manufacture of Finished Traditional Chinese Herbal Medicine (H2), Manufacture and Repairing of Airplanes (H4), Manufacture of Electronic Appliances (H9), Manufacture of Electronic Components (H10), Manufacture of Medical Equipment and Appliances (H16), Manufacture of Measuring Instrument (H17). This also means that most of the industry segments have considerable potential to improve in the efficiency of technological innovation.

4 Conclusion

This paper combines network SBM model and DEA window analysis to evaluate the technological innovation efficiency of high-tech industry in China. The conclusions of this empirical study are as follows:

1. The technological innovation efficiency shows a rising trend in the past 10 years, but the value of innovation efficiency is still low. The international financial crisis has a negative impact on the efficiency of technological innovation of china's high-tech industry in short-term. However, the conversion efficiency has been significantly improved since 2008, which prove that high-tech industry in China has a strong ability to resist risks. In addition, the CV of the overall efficiency and the conversion efficiency are both shrinking continually, but the CV of the R&D efficiency is increasing after 2007.
2. The conversion efficiency has been significantly higher than the R&D efficiency from 2002 to 2011. Furthermore, the outbreak of the international financial crisis makes China's high-tech enterprises pay more attention to enhance the conversion efficiency. The high-tech enterprises in China have pragmatism tendency, and they pay insufficient attention to the efficiency of technological R&D which reflect the industry's core competitiveness.

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Empirical Test the Province and Industry Differences of Financial Restatement in China

Bing Zhou and Qian Zhang

Abstract This paper focuses on the industry contagion effect of financial restatement and the factors that impact such effect by statistically analyzing the differences in the financial restatement among regions and industries in China. With the method of building models and panel regression analysis, the industry contagion effect aroused by the financial restatement among regions and industries is tested via building panel threshold regression model, the test results confirms that the industry contagion effect of the financial restatement exists significant differences among regions and industries. Firstly, industry contagion effect of financial restatement of listed companies exist provincial difference in our country. Industry contagion effect of financial restatement of eastern is most significant, and the central slightly take second place, western province is least significant. In the eastern region, in addition to Guangdong and Hubei, the rest provinces are significant, industry contagion effect of the financial restatement of listed companies is especially significant in Beijing, Tianjin, Shanghai, Jiangsu and Fujian. Only Hunan, Hubei, Henan and Anhui four provinces in the central region are more significant, other provinces are not. And industry contagion effect of financial restatement is the least significant in the western area on the whole, only Guangxi, Chongqing, Qinghai three provinces and cities are significant, and industry contagion effect of financial restatement in other western provinces is not obvious. Secondly, industry contagion effect of financial restatement of listed companies exists industry differences in China. Industry contagion effect of financial restatement on capital material is significant more than consumption material industry and other industries.

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Keywords Communicative average return of restated company • Differences • Financial restatement • Listed companies

1 Measurement Model

To test the financial report of listed companies in our country caused by reproducing the industry contagion effect area and industry difference influence and the intrinsic threshold effect factors, this paper hereby establish three basic models:

$$\text{ICARit} = \text{C0} + \text{C1 CAR it} + \text{C2 CARit}^{*}\text{RESP} + \text{Cj X it} + \varepsilon\text{it} \tag{1}$$

Among them, the ICARit for accumulated excess earnings of companies in the industry; CAR for reproducing company accumulated excess earnings, CAR * RESP for reproducing type and accumulated excess reward cross variables, the classification of restatement type for influence profit restatements and does not affect the profit restatements [1]. Xit for a group of control variables, including industry company's performance, industry the company's capital structure, companies in the industry; funds operation ability, the scale of companies in the industry, the stock right of industry structure, the equity properties of companies in the industry, the characteristic factors of company's board directors.

2 Index Setting

In the choice of index, based on the reference related to the research literature at home and abroad, we select the following variables which show the financial restatement affecting listed companies in the same industry in China.

Industry cumulative Average Return (ICAR): on the market reaction measurement [2], the domestic and foreign scholars roughly use two typical methods: accounting approach and market (events) approach. Accounting approach is using the key financial data or establishing a financial index system to evaluate the company's operating performance, that is comparing the financial performance changes before and after the company restate financial statement, to study the financial restatement events impact on the company [3]. Market (events) approach is mainly compute CAR (Cumulative Average Return) which as the proxy variable quantity to market response, through inspecting ICAR before and after a certain event to show market reaction. In this paper, the financial restatement of the market reaction using event study method, that is computing the cumulative Average return (CAR), as a measurement of financial restatement of the market reaction. ICAR represents the sum of average AR (abnormal return) of window period of industry company. And AR (abnormal Return) is the difference between the actual rate of Return and the abnormal rate of Return. The so-called event window, it is a certain period which tests a particular event impact. We suppose that as the day of particular event, as the day of financial restatement (If the announcement not disclose in the trading day, we take the first trading day after the day of announcement as disclosure day) [4]. Our paper mainly study 5 day's stock returns, liquidity and volatility change around the day of financial restatement [5]. The windows of particular event are −5 and 5 [6].

Communicative Average Return (CAR) of restatement company: CAR means earning rate which surpass normal earning rate of restatement company, the sum of average AR (abnormal return) of window period of restatement company [7]. And AR (abnormal Return) is the difference between the actual rate of Return and abnormal rate of Return. Window of particular event and particular event are the same above.

Restatement company's restatement properties (RESP): namely restatement involved in income, costs and operating expenses, etc. [8]. If the restatement involved in income, costs and operating expenses, it is a core restatement, take 1, otherwise it is a non-core restatement, take 0.

Industry company's achievement (IROA): financial index and market index are commonly used to measure achievement. Considering the tobin Q in the measurement of non-tradable share value is not unified, still has large dispute, our paper use ROE (Rate of Return on Common Stockholders' Equity) index as the measurement of the achievement of industry company.

Industry company's capital structure (CAPS): Capital structure refers to all kinds of capital structure and the proportional relation in a company. In theory, capital structure has generalized and special types: generalized capital structure refers to all the capital structure, namely equity capital and debt capital contrast relationship; special capital structure refers to equity capital and long-term debt capital contrast relationship, and short-term debt capital as operating capital management. The capital structure of enterprise is a systematic, comprehensive result of expected return, capital cost and financing risk and property distribution etc. Thus, capital structure reasonable or not to a great extent determine enterprise's sinking and refunding ability and future profitability [5]. Capital structure in general is the problem of liability proportion issue that is liability proportion in total capital. Our paper uses debt-to-assets ratio as the measurement of company structure.

The size of the industry company (SCAL) [9]: generally speaking, measure the company size can choose number, asset scale and sales, etc. Considering the assets index relative to the use of the index can reduce some of the labor-intensive industry characteristics to estimate the influence of the results, our paper choose the natural logarithm of year-end total assets of company to measure company scale.

Equity structure of industry company (EQUS): using equity concentration ration of share to measure [10]. Concentration ration of share refers to the concentration or dispersion of the quantification index of equity according to the difference in shareholding ratio, namely equity is concentration or dispersion, share quantity and the mount of shareholding ratio of each shareholder. It is a main index to measure share distribution in a company, also an important index to measure the strength of the company stability, it contains the core problem that who control share right. Commonly measurement of equity concentration contains the following several main indexes.

Industry company's equity property (EQUP) [11]: refers to the first big shareholder ownership property of the listed company [12]. Different equity properties will impact corporate governance mechanism, the management goal have a profound influence on decision, and eventually affect the company's profitability and market performance, so the first big shareholder ownership property is different, its management efficiency and the company performance are different. Research has shown that the first big shareholder is a non-state shareholder of the company, then the company management will be more efficiency, and has higher enterprise value and stronger profitability. Therefore, this paper defines as follows: the first big shareholder for state-owned shares, then take 1, the first big shareholder for non-state-owned share, take 0 [13].

Industry company's board of directors characteristics (BOAP) [14]: as the company internal highest supervision institutions, the board of directors through supervising the management to ensure the improvement of the quality of financial statements, and protect the interests of investors. Therefore, the board of directors is the central part in the corporate governance, ensuring the quality of accounting information is the basic responsibility of the board of directors. The efficiency of the board of director depends on independence and professional competence of its members. The composition of the members of the board of directors can be subdivided into internal directors, related outside directors and independent directors. Independent directors are considered to be less association with enterprise management, can fair comment and supervise the company's current managers. The independent directors take their own popularity and reputation into consideration, generally won't collusion with management. The independent directors' rich experience and professional skill helping each item of company governance mechanism can better operate. The audit committee is a special institution set by the board of director, aims to ensure the transparency of company.

Financial, supervises company's financial information, discloses and reviews the company's internal control system, etc. Therefore, the establishment of the audit committee also helps to improve the quality of accounting information. Using the proportion of independent directors and audit committee to measure the board of director's characteristics is more appropriate. In this paper, the proportion of independent directors more than 50 % and setting audit committee of the company takes 1. Variable meaning and index explanation as Table 1.

3 Measurement Result

Because listed companies in different parts, in different industries and each company's capital operation ability are great different, industry contagion effect arose by financial restatement consequences may also be different. Therefore, firstly

Table 1 Variable meaning and index explanation

Index classification	Symbol	Index definition	Index explanation	Expected sign
Explained variable and explanatory variable	ICAR	Industry cumulative Average Return	Industry company actual rate of return minus the sum of the normal expected rate of return in Window period	
	CAR	Communicative Average Return	Restatement company actual rate of return minus the sum of the normal expected rate of return in Window period	+
The main control variable	RESP	Restatement company's restatement property, namely whether restatement affect profit	If the manipulation influence profit, take 1, otherwise take 0	+
	IROE	Industry company's performance	Use return on equity index measure industry company performance, namely after-tax profit divided Stockholders' equity	−
	CAPS	Industry company's capital structure	Use asset-liability ratio to measure the company's capital structure, namely total liabilities divided the ratio of the end of year total assets	+
	SCAL	The size of the industry company	The natural logarithm of year-end total assets of company to measure company scale	+
	EQUS	Industry company's equity structure, mainly focus on equity concentration	The sum of the ratio of former three big shareholders shareholding	+
	EQUP	Industry company's equity property, mainly refers to the first big shareholder ownership property of the listed company	The first big shareholder for state-owned shares, then take 1, the first big shareholder for non-state-owned share, take 0	+
	BOAP	Industry company's board of directors characteristics, mainly refers to the board of directors structure, whether set up the audit committee, etc.	Focus on independent director in the board of directors proportion, whether set up the audit committee, if the proportion of independent directors large and set up audit committee, then take 1, otherwise take	−

inspecting the different contagion effect caused by financial restatement among different areas and industries in our country. This paper using model 1 to test the difference contagion effect arose by financial restatement in different areas and industries, the empirical results see Tables 2 and 3.

4 Conclusion

From the result of regression in Tables 2 and 3, we can find that R2 all around 0.7 after adjustment in this two model, indicates that multiple regression model is good. DW are 1.79 and 1.87, closes to 2.0,variable and not existing sequence correlation on the whole, indicates that contagion effect of financial restatement of listed companies in our country impacting on industry company has different characteristics in regional and industry. From the empirical results of Table 2 can be found, financial restatement's provincial difference of industry contagion effect is obvious. Contagion effect of financial restatement of industry company is most significant in the eastern province, and the central slightly take second place, the west is less significant. The eastern region, in addition to Guangdong and Hebei, the rest of the provinces are significant, the contagion effect of the financial restatement of listed companies are especially obvious in Beijing, Tianjin, Shanghai, Jiangsu and Fujian. Quotient β1 are positive and large. Only Hunan, Hubei, Henan and Anhui four provinces in the central region are more significant, other provinces are not significant. And the western area industry contagion effect caused by the financial restatement on the whole is not significant, only Chongqing, Yunnan are significant, and contagion effect in other provincials are not obvious. This empirical indicates that contagion effect caused by financial restatement is more obvious in developed areas reaction than in less developed areas.

In model of Table 2, from the quotient β1 and T-values of restatement company's restatement property (RESP) (whether a core restatement), industry company's performance (IROE) [15], industry company's capital structure (CAPS) [16], the size of the industry company (SCAL) [17], industry company's equity structure (EQUS), Industry company's equity property (EQUP), Industry company's board of directors characteristics (BOAP) [18], we can find that other variables will be significant or not significant arise industry contagion effect except that Industry company's performance (IROE) and industry company's board of directors characteristics (BOAP) have opposite effect. Especially restatement company's restatement properties (RESP) variable significant positive influence Industry cumulative Average Return (ICAR) [19], If financial restatement involves income or cost which are core restatements, to the industry company's contagion effect influence coefficient is 0.0046. And industry company's capital structure (CAPS) to company's contagion effect influence coefficient is 0.051 [6].

We can find the difference of industry contagion effect in different industry by Table 3. If company financial restatement is the core restatement, industry company's contagion effect influence coefficient is 0.0024.In other control variables,

Table 2 Results of variable coefficient model test of difference contagion effect arose by financial restatement in different between 2003 and 2011

East province			Middle province			West province		
Province	Quotient C_i	T-values	Province	Quotient C_i	T-values	Province	Quotient C_i	T-values
BeiJing	0.002	3.01*	ShanXi	0.019	1.80	GuangXi	0.044	1.79
TianJin	0.001	2.13**	AnHui	0.032	2.17**	SiChuan	0.065	1.32
ShangHai	0.013	2.07**	HeNan	0.022	1.05	ChongQing	0.040	2.10***
GuangDong	0.001	0.89	JiangXi	0.017	1.09	GuiZhou	0.004	1.04
HeBei	0.006	1.56	HeNan	0.003	2.23**	YunNan	0.071	1.91***
JiangSu	0.071	2.36**	HuBei	0.064	1.95**	QingHai	0.011	1.07
ZheJiang	0.033	1.98***	HuNan	0.075	2.27**	ShaanXi	0.005	1.77
FuJian	0.002	2.33**	JiLin	0.027	1.64	GanSu	0.002	1.22
ShanDong	0.036	3.09*	HeiLongJiang	0.007	1.34	NingXia	0.055	1.72
LiaoNing	0.005	2.03**	NeiMengGu	0.026	2.73*	XinJiang	0.044	1.50
RESP		0.0046 (3.63*)			IROE		−0.0031 (2.75*)	
CAPS		0.0045 (1.72)			SCAL		0.051 (2.30**)	
EQUS		0.009 (1.67)			EQUP		0.0011 (1.17)	
BOAP		−0.0327 (2.67**)						
Adjustment R^2		0.73			F-statistics		67.33	
D.W.		1.79						

Notes:
(1) In this paper the measurement results completed by Eviews5.1 package, numbers in bracket refers to t test value of the Parameters. *, * *, * * * respectively represent significance level in 1 %, 5 %, 10 %
(2) The result of regression omitted constant term

Table 3 Results of variable coefficient model test of difference contagion effect arose by financial restatement in different industry

Industry	Quotient C_i (T-values)		Quotient C_i (T-values)
Primary industry	0.086 (1.85)	Agriculture, Forestry, Husbandry and Fishery	0.086 (1.85)
Secondary industry	0.026 (2.04***)	Mining industry	0.01 (1.49)
		Manufacturing industry	0.07 (2.68**)
		Real Estate Industry	0.03 (1.99***)
		Energy industry	0.007 (1.52)
Tertiary industry	0.034 (1.87)	Transportation storage and postal service	0.002 (1.55)
		Information industry	0.004 (1.13)
		Wholesale and Retail	0.014 (1.97***)
		Tourism industry	0.001 (1.28)
		Synthesise industry	0.006 (1.84)
RESP	0.0024 (2.33***)	SCAL	0.007 (2.01***)
IROE	0.0025 (1.29)	EQUS	0.004 (1.39)
CAPS	−0.006 (1.97***)	EQUP	0.0009 (1.29)
BOAP		0.002 (1.80)	
Adjustment R^2		0.68	
D.W.		1.87	
F-statistics		49.84	

Notes:
(1) In this paper the measurement results completed by Eviews5.1 package, numbers in bracket refers to t test value of the Parameters. *, * *, * * * respectively represent significance level in 1 %, 5 %, 10 %
(2) The result of regression omitted constant term

only industry company size variable is a significant positive influence as a industry company contagion effect, influence coefficient is 0.007, and industry company's capital structure is a more significant negative influence as a industry company contagion effect, influence coefficient is negative 0.0065. The empirical results also show that company financial restatement make a positive influence to the second industry company, and influence coefficient is 0.026, specifically, announcement company's financial restatement make a remarkable influence on the listed company of manufacturing and real estate industry, and the influence coefficient are 0.07 and 0.03, financial restatement a significant positive effect, influence coefficient is 0.014, indicating that financial restatements of listed companies of our country cause different industry contagion effect in different industry.

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Mechanism and Model of Rural Innovation Development System Formation Based on Knowledge Network Embedding

Jing Tian and Yun Zeng

Abstract Knowledge has become the main factor for the rural development in era of knowledge economy. The rural innovation system based on Knowledge Network (KN) realizes knowledge flow and knowledge creation between the main elements, and make the rural innovation system innovation capability remained at a high level. In this paper, Based on introduction to KN and rural innovation system as well as their relationship, the mechanism and model of rural innovation system formation based on KN is analyzed, which may contribute to understanding the significance of formation of rural innovation system and KN in the development of rural innovation system.

Keywords Knowledge network • Mechanism • Model • Rural innovation system

1 Introduction

Innovation development model of rural has transformed of the traditional linear innovation model into nonlinear models. That the conventional emphasis on linear innovation processes—moving knowledge from scientists to extension agents to farmers—is an over implication of complex processes that are highlighted by non-linear learning processes, feedback loops, and other complex interactions that occur among far more heterogeneous actors [1]. Knowledge, Innovation and Consensus Spaces show the process and mechanisms by which the institutional spheres interact

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and co-evolve over time. The specific activities and formats of the Spaces provide guidelines for integrating endogenous and exogenous strategies [2]. The network path of rural construction is connection between the developments of endogenous (local, bottom-up development) and exogenous (outside the local, top-down), the development mode emphasizes the importance of space allocation efficiency and innovation factors such as knowledge and technology. Knowledge, learning and social capital are composed of three main sources of rural innovation ability, based on this, the paper from the perspective of the Knowledge Network (KN), to research the mechanism and model of the rural innovation system, which expect improve the efficiency and level of innovation and promote the smooth operation of rural innovation system.

2 KN and Rural Innovation System

2.1 KN

An understanding of knowledge networks is vital to understanding knowledge creation and economic growth: Knowledge production and diffusion, which are central to explaining economic growth [3], are increasingly the result of collaborative relationships among individuals, groups, and organizations [4], and collaboration can improve the quality and economic value of newly created knowledge [5]. Knowledge network is the needs of knowledge demand and knowledge management formed by a plurality of sets knowledge chain which is a network system including of knowledge sharing, knowledge integration, knowledge creation and other functions. a knowledge network as a set of nodes—individuals or higher level collectives that serve as heterogeneously distributed repositories of knowledge and agents that search for, transmit, and create knowledge—interconnected by social relationships that enable and constrain nodes' efforts to acquire, transfer, and create knowledge [6].

2.2 Rural Innovation System

The concept of rural development is above all a heuristic device. It represents a search for new future and reflects the drive of the rural population. It goes beyond modernization theory where the problems of agriculture and the countryside were considered resolved. Definitive answers, however, are missing and if offered should be mistrusted. Rural development theory is not about the world as it is—it is about the way agriculture and the countryside might be reconfigured. Rural construction is a network of economic, political and institutional, can promote knowledge spread rapidly and the best performance in the collective learning process, which support by the rural clusters surrounded. Rural innovation system is take the knowledge as strategic resource, take KN of innovation organization interactive learning as the basis, and take create, spread, application of knowledge as the core, which is a social network system in order to promote the upgrading of the structure of rural economic and social development purpose.

2.3 The Correlation Between KN and Rural Innovation System

There are four key requirements for the success of a rural district, understood as a socio-economic network: flexibility, competences, efficiency and synergy. The network paradigm seeks to establish a ‘third way’ [7] or synthesis between endogenous (local, bottom-up) and exogenous (extra-local, top-down) links in order to foster learning and innovation processes. Powell (1990) argues that it is the open-ended, relational features of networks that facilitates transfer and learning of new knowledge and skills [8]. Latour (1986) sees networks as sets of power relations where power lies in the links that bind the actors and entities together [9]. Murdoch (2000) seeks to identify the role of networks in the formulation of rural development strategies. For this he identifies two axes of networks: vertical and horizontal [10]. According to Gusztáv NEMES, Integrated rural development is an ongoing process involving outside intervention and local aspirations; aiming to attain the betterment of groups of people living in rural areas and to sustain and improve rural values; through the redistribution of central resources, reducing competitive disadvantages for competition and finding new ways to reinforce and utilizes rural resources. Integrated rural development systems, in this understanding, are particular setups of central and local institutions (such as: administration, knowledge, information and decision-making systems, social networks), working in coherence and so being able to realize the ideas of integrated rural development theory [11]. Innovation development of rural areas, one hand, needs the support of national policy, macro guidance and planning to go beyond the small interests of community, and timely response to the rural society; on the other hand, needs relatively independent space of the rural power, so as to ensure the rural social demands orderly collection, timely and smoothly into the political system. In addition, the rural construction also requires third party intervention, the third force is different from the government and the villagers, refers to individual, community and other whom participate rural construction to self-realization their value. The three groups have different knowledge, ability and resources, When the three together, can effectively promote the rural construction. Therefore, when the subject of KN comes into the rural innovation system, it became the subject of rural innovation system. The main elements of KN and rural innovation system are individuals, organizations, research institutions, government, intermediary institutions, they has a great coincidence.

The main function of the rural innovation system is the creation, diffusion and application of new knowledge. The main function of KN is through interactive cooperation network to achieve effective knowledge creation, and promote the diffusion of knowledge within the network flow. In this sense, KN and rural innovation system has a great overlap in function. The direct purpose of the construction of rural innovation system is to promote effective allocation of knowledge resources, promote the upgrade and innovation of rural industry, the ultimate goal is to improve the rural innovation ability, and the competitive advantage. The goal of KN is improve the industry and country competitiveness, is closely related with the goal of building the rural innovation system through innovation network to improve innovation efficiency, significantly reduce the innovation cost. It is because of the correlation between KN and rural innovation system in many aspects, so KN has great influence to rural innovation system, which is the important carrier of rural innovation system.

3 Mechanism of Rural Innovation System Based on KN

Knowledge is the most important factor of production in rural innovation system. Because of rural innovation system have several of formal or informal interactive learning, which make the research and development activities of each main of the rural innovation system producing knowledge overflow. Knowledge overflow enable improve the subject more closely interactive, make the innovation system strengthening in constantly connection, so knowledge overflow is a necessary condition for the formation of rural innovation system. Knowledge flow is the knowledge creation process based on knowledge overflow, the knowledge transfer, sharing, and diffusion of inter-subjective interaction. Innovation is the result of knowledge flows, so knowledge flow is the fundamental guarantee of the formation of rural innovation system. Knowledge overflow and knowledge flow together promote the formation of rural innovation system.

3.1 Knowledge Overflows Effect of Rural Innovation System Based on KN

The innovation advantages of rural innovation system is that it will integrate the rural, universities, research institutions, government and intermediary service organizations together, between the innovation main body, the contact is not loose, but form a close KN, each network node will have knowledge overflow. Through the KN, the main innovation in rural areas can not only obtain the explicit knowledge, but also can obtain more important tacit knowledge. In general, knowledge overflow can be divided into horizontal and vertical overflow, the horizontal knowledge overflow flow between the similar nature of the innovation subject, and vertical knowledge overflow is carried out between the different of the innovation subject. The knowledge's overflow effect of rural innovation system is the fundamental driving force for promoting the rural production cooperative and rural economic growth.

3.2 Knowledge Flow of Rural Innovation System Based on KN

Organizational Relationship form of the rural innovation system is "knowledge flow". A knowledge flow represents the flow of an individual's or group members' knowledge-needs and the referencing sequence of documents in the performance of tasks [12]. Knowledge flows include four critical behaviors; those through which that knowledge becomes available to the organization (acquisition), those involved in retaining that knowledge, the transfer of knowledge within the organization, and it use in enabling the actions and decisions that comprise the business process [13]. The knowledge is flowing in the network of rural innovation system. Knowledge flow is flow process knowledge in Colleges and universities, scientific research institutions, rural, government and intermediary service organization system. The essence of knowledge flow is promoting the effective combination of innovation elements. Knowledge flow is an important mode of interaction between elements, the scale and efficiency of knowledge flow directly affects the structure and operational efficiency of the rural innovation system, strengthening the knowledge flow between the elements is the fundamental task of the rural innovation system. Knowledge flow made knowledge resources effectively configuration and efficient using. Through the flow of knowledge, the innovation subject of rural innovation system can acquire new or complementary knowledge of science and technology, and the large number of explicit knowledge and tacit knowledge acquisition is a prerequisite for all new activities started. Through the platform of rural innovation system based on knowledge flow, knowledge innovation will be required for integration, through learning, application, the creation of knowledge to improve the level of knowledge management, so as to seek a wider space for survival and development.

The original innovation knowledge resources often come from the original knowledge and innovation technology research of universities and research institutions. Knowledge flows can be the original innovation knowledge resources into the rural innovation system, and realize the sharing, diffusion and transfer of knowledge in the system, and finally transformed into practical productive forces. By means of the knowledge flow, knowledge innovation has been popularized in rural innovation system and realize effective configuration, so as to continuously produce new economic growth point, promote the benign operation and sustainable development of rural innovation system.

The relationship between the elements of rural innovation system is not linear, but there exist interactive relation. The operation effect of rural innovation system depends on the knowledge creation and use of the elements Mutual contact, including cooperation, personnel flow, patent pool, and equipment introduction. The contact of elements is core in innovation system, and knowledge flow provides the operation platform for elements contact. Elements contact achieves the birth of innovation as the carrier of knowledge flow.

4 The Rural Innovation System Model Based on KN

The elements of KN include knowledge, people, institutions, knowledge management, knowledge chain, technology, innovation environment etc. The characteristic of KN are complex, highly technical, and the interdisciplinary. From the object, KN includes three aspects that are information technology, human resources and information resources. In the comprehensive consideration of the factors of cost, the speed of information transmission, information transmission mode, we think rural innovation system based on KN is composed of user layer, knowledge integration and knowledge communication layer, and knowledge storage layer (shown as Fig. 1). Among them, the user layer is the basis of knowledge, knowledge integration and communication is the core, the coupling of three systems is the key.

4.1 The Layer of Knowledge User

The user layer of rural innovation system based on KN mainly includes rural, scientific research institutions, government, intermediary service organization innovation and innovation main bodies and the platform of knowledge sharing. The main innovation including into a knowledge sharing platform can avoid unnecessary cost losses caused by unsmooth communication, reduce the transaction cost, also can greatly improve the using efficiency of knowledge, to eliminate the barrier of rural innovation development system, and make the knowledge resources optimal allocation.

Along with the rural integrated development, professional and standardized of participation rural areas economic activities appears to be reduced and simplified, which means that the thinking mode of development has been changed, the local knowledge of village recognized, local human capital, social capital, and cultural capital, natural capital is considered an important foundation in the rural development. The innovation is the important foundation of rural innovation system. The innovation ability of rural is an important sign of the rural competitive ability. In the rural innovation development system, farmers have always been the core subject of innovation, undertaking the important task to promoting innovation rural and rural industry development.

Colleges and universities are gathering talents, intelligence resources is in rich, library information and network database constitutes a powerful information network, a national laboratory, advanced equipment and research facilities, and different universities, different disciplines frequent exchanges and cooperation to promote knowledge creation, these characteristics make both Explicit knowledge and tacit knowledge can flow in the wide, which advantage of knowledge creative. The final goal of knowledge creation is the realization knowledge application, promote economic growth, therefore, the knowledge creation is not isolated, which must needs Participate of the scientific research institutions and rural user layer, and with the support of the government and intermediary service organization, to realize transformation the science and technology into practical productive forces.

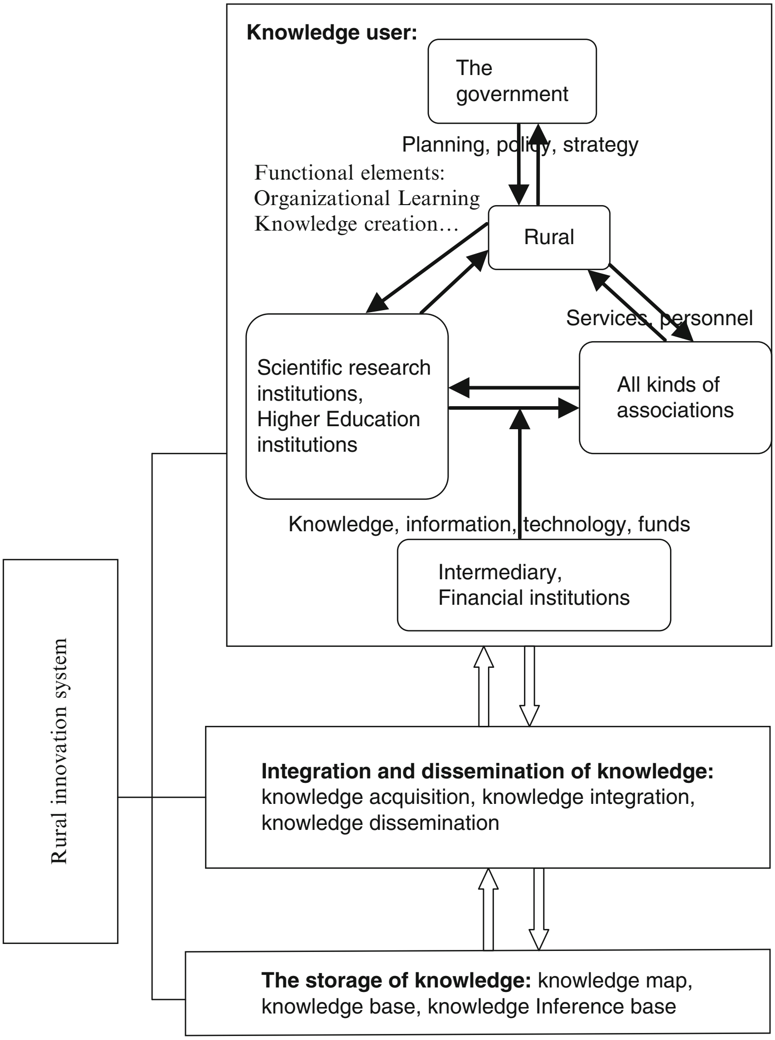

Fig. 1 Rural innovation system model based on KN

Scientific research institutions is the structural unit of the most innovative in rural innovation system, which focus on science and technology innovation and personnel training, and have the rich research resources, outstanding scientific and technological personnel, advanced scientific research equipment and the strong support of government policy. Between the scientific researches institutions maintain close exchanges and cooperation, and they have supported from the colleges and universities, these features make it plays a dominant role in the new knowledge creation, dissemination and diffusion process. However, the linkages between scientific research institutions and market are not close as rural; it determines the relative weakness in the market and technical knowledge achievements. The role of scientific research institutions is contact the college as the main body of knowledge innovation, and support rural technological innovation and industrial innovation, so as to promote the rural innovation. The construction of rural innovation system is complex system engineering; the government is an important main body in the system, which plays the overall co-ordination role. Generally speaking, in the countryside innovation system, the government's focus is to establish the service regulations and policies, construction environment, the coordination of services, strengthen supervision, the allocation of resources, especially pay attention to the construction of service environment. Created a good rural innovation environment has become a kind of policy measures to enhance competition in many countries. Intermediary service organization is an important part of the innovation system of knowledge flow, which is institutions to provide information, trading services, intermediary services, financial and insurance to both sides of supply and demand. The consulting service intermediary organization of different levels, different areas are a bridge between colleges and universities, scientific research institutions and rural knowledge flow, which promote the diffusion of knowledge, improve the degree of knowledge sharing, and is an indispensable part of country innovation system. Many governments have been attention to the construction of intermediary service organization. Because knowledge is lossless and non-exclusive, therefore, knowledge resources is not easy to protect, which has characteristics of public goods. The knowledge of the repeated using and consumption will not only make the loss is reduced, but will bring knowledge value-added. The main elements of various rural innovation system user layer close cooperation and personnel interaction objectively formed knowledge resources sharing in rural areas. Through knowledge sharing, the main factors can be obtained directly from gains the other knowledge creation.

4.2 The Layer of Knowledge Integration and Dissemination

Integration and dissemination of knowledge as the carrier of knowledge resource, which appropriate storage integration the original knowledge and new knowledge of user layer, and concentrate all kinds of knowledge scattered in all main innovation to the integration layer, solves the problem of the knowledge resources scattered in rural innovation system, and prepare for the knowledge communication, but also to avoid the tacit knowledge resources loss due to personnel loss. The integration of knowledge resources mainly through various means, to collate combination knowledge collected from each innovation subject and variety domains, this knowledge may be is already sorted before, may be also scattered. The knowledge integration of rural innovation system is mainly divided into two levels: micro and macro. Micro level mainly refers to the integration of technology and relevant knowledge experience between internal departments production in the actual work; the macro level refers to the knowledge integration based on knowledge flow between innovation subjects.

Regardless of the micro or macro level knowledge integration, they should continue to collect knowledge communication layer, service for the sustainable development of the rural innovation system. The dissemination of knowledge is mainly realize by the various ways cooperation, communication, learning imitate, through the transfer of technology, the outcome industrialization, transactions of knowledge patent, the flow of talent, the sharing information resources and other forms to realize knowledge flow and optimized allocation in rural innovation system. The layer of knowledge integration and communication is the core layer in the rural innovation system. It integrate the knowledge obtain a variety of channels and dissemination to users. In the knowledge integration and communication layer, knowledge management should be carried on the effective, the knowledge can be fast, accurate collection—integration—Communication—collection......, thus forming a convenient knowledge circulation layer, and then improve the efficiency of the use of knowledge.

4.3 The Layer of Knowledge Storage

Knowledge storage layer mainly includes the knowledge map, knowledge repository and knowledge database. Knowledge map mainly classified and consolidation of knowledge, and formatted reasonable classification, the clarity of the knowledge database. This will not only cost and time saving in search knowledge, but also for the body of knowledge using, also easy to grasp, search more convenient. In addition, knowledge map can also achieve real-time eliminating redundant knowledge, to ensure knowledge providing more clarity. Knowledge library store that explicit knowledge including data, text, formula, pictures, video, which facilitate the exchange and sharing. The explicit knowledge mainly includes data, document data, image data, and multimedia data, for the user to quickly and accurately find their needed document. Knowledge inference base is stored tacit knowledge rooted in personal experience, exist in people's mind, hard coding, highly personalized, these tacit knowledge generally require face-to-face contact in order to achieve knowledge sharing and absorbed directly.

5 Conclusion

Three main differences can be highlighted in rural innovation development based on knowledge network embedding. One concerns the flow of resources, the second the flow of information, and thirdly the level of advancement and/or institutionalization of local development systems. Knowledge flows are the movement and availability of information. Knowledge is somewhat loaded in that it is often taken to infer the 'correctness' of information. The propriety of knowledge not only depends on its context of application but also that a degree of relativity is necessary in order to respect and facilitate the interplay between different sources of knowledge. We define capacity building as enhancing the ability to make optimal use of resources [14].

KN and rural innovation system is a hot research field in china in recent years, how to apply KN in the development of rural innovation system, so as to improve agriculture and the rural areas competitive strength in the economic system, has become many rural experts and scholars continuing to explore the issue. From the KN dimension, we discuss the inherent mechanism and model of the rural innovation system, which may played a certain role to promote the rural development.

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Research on the Selection of Construction Supplier in the Construction Supply Chain Environment

Wei-yan Xie and Xing Bi

Abstract Guided by supply chain management thinking, the paper discusses the principles that the supplier evaluation index system should follow. Combined with the characteristics of the construction works, a specific index system is established. After the comparison of several evaluation methods, the paper points out that the grey relational analysis is more suitable for selecting construction suppliers. In the last part of the paper, a numerical example is used to illustrate the rationality and feasibility of the method. The content stated in the paper provides scientific basis for construction enterprises to select suppliers.

Keywords Construction supply chain • Gray relational analysis • Index system • Supplier selection

1 Introduction

Supply chain is a concept that has originated and flourished in the manufacturing industry. In 1980s, Koskela Professor made a speech that applied the manufacturing supply chain model to the construction industry when he was a visiting scholar at Stanford University [1]. Since then, the prototype of the supply chain management mode in the construction industry formed. Nowadays, the competition between the enterprises has turned into the competition between the supply chains. Therefore,

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the scientific and rational selection of partners is more important than before. The construction materials consumed often account for more than 50 % of the project investment. The material supply situation of the supplier directly influences the project schedule, quality and cost control. So it is really important to select the proper supplier to improve the competitiveness of the entire supply chain. Therefore, how to properly evaluate and select the appropriate construction suppliers is at the top of the priority list.

2 The Establishment of the Supplier Evaluation Index System

2.1 The Principles of the Evaluation Index System

Supply chain management must be properly formulated, strategically planned, organized and executed [2]. The application of supply chain management model has put forward higher requirements on the supplier's product quality, manufacturing flexibility, timeliness of delivery and the capability of rapidly responding to the changing needs. Thus, a set of scientific index system is definitely necessary to conduct a comprehensive study of the supplier's overall strength. There are several principles that a supplier evaluation index system should follow.

1. *Principle of being systematic and comprehensive*: The index system should be able to fully reflect the comprehensive strength of the suppliers. Associated with the total target of the supply chain, it should be a hierarchical system that each index is functioning adequately to ensure the comprehensiveness and effectiveness of the evaluation results.
2. *Principle of being flexible and practical* [3]: Each project has its own characteristics, which requires the supplier evaluation system to be flexible, enabling the construction enterprises to adjust the index system according to the specific application environment. In addition, the index system should also have a moderate scale that meets the evaluation needs.
3. *Principle of combining qualitative indexes and quantitative indexes*: The overall strength of the suppliers is influenced by a lot of factors. The quantitative indexes are more operational and comparable, but there are still some factors that can't be fully reflected by quantitative indexes, such as the corporate reputation, development potential. Therefore, the index system should combine the quantitative indexes with the qualitative indexes together to achieve the comprehensive evaluation of the supplier.
4. *Principle of being reconfigurable and scalable* [4]: The demand for suppliers will change with the changing market environment, so the index system should be reconfigurable, enabling the construction companies to make the necessary

Table 1 The supplier evaluation index system

Goal layer	Criterion layer	Index layer	Index type
Supplier evaluation index system	Product system	ISO certification rate [5]	Quantitative
		Rate of qualified products	Quantitative
		Quality inspection and test conditions	Qualitative
		Price reasonableness	Quantitative
		Logistics costs	Quantitative
	Supply capacity	On-time delivery rate	Quantitative
		Order lead time [6]	Quantitative
		Flexibility	Quantitative
	Technology research and development	R&D funds rate	Quantitative
		New product R&D capabilities	Quantitative
		Ability to adapt to new technology	Qualitative
	Comprehensive evaluation	Financial condition [7]	Qualitative
		Social benefits	Qualitative
		Cooperation capacity	Qualitative
		Corporate reputation	Qualitative
		Status of industry	Qualitative

adjustments depending on the actual situation. In addition, with the continuous development of the construction industry, new demand for suppliers will show up, so the supplier evaluation index system should be scalable.

2.2 The Supplier Evaluation Index System

Combined with the characteristics of the construction industry, we constructed a supplier evaluation index system with three levels under the guidance of the above principles, as specified in Table 1 below.

1. *The product system*: ISO certification rate is the ratio of the number of ISO-certified to the number of ISO-certifications needed. Rate of qualified products means the ratio of the number of qualified products to the total procurement. Quality inspection and test condition means the level of soundness of the relevant systems, such as the scientific methods used, advanced tools adopted. Price reasonableness means the ratio of the price of product evaluated to the average price in the industry. And the logistics costs include ordering costs, transportation costs and inventory costs.
2. *The supply capacity*: The supply capacity of the supplier is directly related to the smooth and effective running of the entire supply chain. On-time delivery rate can be measured by the ratio of the number of on-time delivery to the total

number of delivery over a period of time. The on-time delivery rate is directly related to the level of the safety stock of construction companies. Order lead time means the interval between the proposed order and received order. The shorter this interval, the stronger the response capacity of the supply chain to customer demand. The flexibility reflects the response capacity of the supplier to the objective environment, including the production flexibility and delivery flexibility. The formulas are given as follows.

The production flexibility reflects the capacity of changing the level of output to meet the changing needs of the construction enterprises which can be expressed by the probability of changes in demand. Assuming that demand of the construction enterprise is a random variable that obeys the normal distribution. It can be expressed as, $D \sim N(\mu, \sigma_D^2)$. And the production flexibility can be calculated by the formula: $f = \Phi\left(\frac{Q_{max} - d}{S_d}\right) - \Phi\left(\frac{Q_{min} - d}{S_d}\right)$, Q_{max} and Q_{min} in the formula respectively means the maximum and minimum yield on the basis of profit. d is the average demand of the N-periods. And S_d is the standard deviation of d.

The delivery flexibility reflects the capacity of changing the planned delivery time which can be measured by the ratio of the slack time of the delivery to the entire delivery period. Assuming that there are $j = 1,2, \ldots J$ tasks in the system. And t is the current time, L_j is the latest time of task j, E_j is the earliest time of task j. Then, the delivery flexibility can be calculated by the formula: $f = \frac{\sum_{j=1}^{J}(L_j - E_j)}{\sum_{j=1}^{J}(L_j - t)}$.

3. *Technology research and development*: The fund invested provides the economic basis to enhance the innovation capability which can be measured by the proportion of the fund invested to the sales revenue during the same period. New product research and development capacity refers to the ability of bringing new products to the market through research and development activities. And it can be measured by the ratio of sales of new products to the total sales of the products during a certain period of time. The ability to adapt to the new technology is the ability of timely adopting the new technologies and new techniques which can be measured by expert scoring method.
4. *Comprehensive Evaluation* [8]: The financial condition reflects the management capacity of the suppliers which can be evaluated by the financial indexes, such as the total assets turnover, asset-liability ratio and return on total assets. Indexes of social benefits evaluation reflect the requirements of the development of recycling economy and green supply chain which can be evaluated by environmental impact degree, energy consumption, recycling utilization, and environmental reputation. Cooperation capacity includes cooperate attitude, communication effectiveness and the information management level. Corporate reputation and status of industry can be evaluated by experts.

The above content is a brief explanation of the indexes and the construction enterprises can make appropriate adjustments if necessary to choose the right suppliers.

3 Evaluation Methods

After the establishment of the supplier evaluation index system, the next step is to select the appropriate evaluation method to select the right supplier. The evaluation results may be different due to the different methods selected. After a simple research of the common methods of evaluation and selection of suppliers, the paper proposes the grey relational analysis method which is based on the gray theory.

3.1 Common Methods

An appropriate evaluation method is the theoretical basis of the scientific selection of suppliers. Nowadays, commonly used methods include qualitative methods, quantitative methods and the combination of qualitative and quantitative methods.

The qualitative methods commonly used include intuitional judgment, bidding and negotiation. These methods rely mainly on the past experience and the strong subjectivity fails to truly reflect the actual situation of the suppliers evaluated, so these methods are not commonly used in the practice.

Common quantitative methods include procurement cost method, ABC cost method. These methods mainly consider the cost factors. However, there is also some significant information that can not be quantified. Because of the limitation, these methods fail to meet the construction enterprises' need to select suppliers.

The last category of methods includes analytic hierarchy process, artificial neural network method, data envelopment analysis and integrated scoring method. Because of the advantage of being able to fully reflect the actual situation of the suppliers evaluated, these methods are used more frequently. However, these methods also have their own problems. For example, the judgment matrix in analytic hierarchy process is influenced by subjective factors and the consistency of judgment matrix is difficult to achieve. The artificial neural network is too complex to apply in practice and lack of operability. Based on the comprehensive consideration, this paper chooses the comprehensive evaluation method based on gray relational analysis to evaluate and select suppliers.

3.2 Supplier Evaluation Model

Gray relational analysis is a comprehensive evaluation method based on gray theory which determines the relevance by determining the closeness of geometric curves of the reference sequence and the comparative sequences. The relevance of geometric curves is reflected by gray related degree. The greater the degree of relevance, the better the evaluation result. If a comparability sequence translated from an alternative has the highest grey relational grade between the reference sequence and itself, that alternative will be the best choice [9]. The detailed modeling process can be described as follows [9, 10]:

1. Determine the evaluation standard (reference sequence) and the evaluation objects (comparative sequences). Assuming that there are m evaluation objects and n evaluation index, the comparative sequences:

$$X_i = \{X_i(k)\,|k = 1, 2, \ldots, n\}, i = 1, 2, \ldots, m$$

The dimensionless and standardized data is necessary to conduct the later analysis to get the comparable data. The formula (1) is for the benefits indexes and the formula (2) is for the costs indexes. And $\max X_i(k)$ and $\min X_i(k)$ in the formula respectively represents the minimum and maximum value of the k index among the m evaluation objects.

$$X_i(k) = \frac{X_i(k) - \min X_i(k)}{\max\limits_i X_i(k) - \min\limits_i X_i(k)} i = 1, 2, \ldots, m; k = 1, 2, \ldots, n \tag{1}$$

$$X_i(k) = \frac{\max X_i(k) - X_i(k)}{\max\limits_i X_i(k) - \min\limits_i X_i(k)} i = 1, 2, \ldots, m; k = 1, 2, \ldots, n \tag{2}$$

2. Determine the corresponding weight of each index.
The optional methods include the analytic hierarchy process, entropy weight method [11] and so on.
The corresponding weight of each index: $W_k = \{X_k|k = 1, 2, \ldots, n\}$. W_k is the corresponding weight of the k evaluation index.
3. Calculate the gray relational coefficients.
The formula:

$$\xi_i(k) = \frac{\min_i \max_k |X_0(k) - X_i(k)| + \xi \max_i \max_k |X_0(k) - X_i(k)|}{|X_0(k) - X_i(k) + \xi \max_i \max_k |X_0(k) - X_i(k)||} \tag{3}$$

$\xi_i(k)$ is the relative difference between comparative sequence X_i and reference sequence X_0 in the k evaluation index. Generally ξ takes 0.5.
4. Calculate the gray weighted incidence degree.
The formula:

$$r_i = \frac{1}{n}\sum_{k=1}^{n} W_k \xi_i(k) \tag{4}$$

r_i is the gray weighted incidence degree of the i evaluation object. Sort the evaluated objects according to the correlation degree and select the best evaluation object.

Supplier selection is widely considered to be one of the most important responsibilities of management. Having different criteria including conflicting criteria such as quality and price can create more complexity to the supplier selection decision, which is a multicriteria decision making problem [12].

The above content gives the basic principles of the gray relational analysis. A brief introduction of steps of conducting grey relational analysis is presented. Our objective here is to implement and examine the method in the numerical example to illustrate the feasibility and practicality of the method.

4 Numerical Example

A project purchasing department intends to conduct a comprehensive evaluation of four alternative suppliers and the results of the evaluation will be used for the supplier selection decision. According to the company's specific circumstance and requirements of the project, the purchasing department adopts the following evaluation index system. The values of the index of the suppliers are given according to the index formula and evaluation criteria of qualitative indexes previously described. The data has been standardized by formula (1) and formula (2), as shown in Table 2 [13, 14].

Table 2 Standardized index value

Evaluation indexes	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Optimal value
ISO certification rate	0.6250	1	0.8438	0	1
Rate of qualified products	0.3333	1	0.6667	0	1
Quality inspection and test conditions	0.9912	0	1	0.4425	1
Price reasonableness	0.7143	1	0.4286	0	1
Logistics costs	0.6667	0.3333	0	1	1
On-time delivery rate	0.5000	1	0	0.5000	1
Order lead time	0.6429	0.9286	0	1	1
Flexibility	0.6667	0.3333	0	1	1
R&D funds rate	0.6563	1	0	0.3438	1
New product R&D capabilities	0.2941	0.8431	1	0	1
Ability to adapt to new technology	0.3333	0.6667	0	1	1
Financial condition	0	1	0.6863	0.5882	1
Social benefits	0	0.7000	1	0.5000	1
Cooperation capacity	0	0.7143	0.4286	1	1
Corporate reputation	0.5000	0	1	0.5000	1
Status of industry	0.6252	1	0.4018	0	1

Table 3 Correlation coefficient

Evaluation index	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Optimal value
ISO certification rate	0.5714	1	0.7619	0.3333	0.5714
Rate of qualified products	0.4286	1	0.6000	0.3333	0.4286
Quality inspection and test conditions	0.9826	0.3333	1	0.4728	0.9826
Price reasonableness	0.6364	1	0.4667	0.3333	0.6364
Logistics costs	0.6000	0.4286	0.3333	1	0.6000
On-time delivery rate	0.5000	1	0.3333	0.5000	0.5000
Order lead time	0.5833	0.8750	0.3333	1	0.5833
Flexibility	0.6000	0.4286	0.3333	1	0.6000
R&D funds rate	0.5926	1	0.333	0.4324	0.5926
New product R&D capabilities	0.4146	0.7612	1	0.3333	0.4146
Ability to adapt to new technology	0.4286	0.6000	0.3333	1	0.4286
Financial condition	0.3333	1	0.6145	0.5484	0.3333
Social benefits	0.3333	0.6250	1	0.5000	0.3333
Cooperation capacity	0.3333	0.6364	0.4667	1	0.3333
Corporate reputation	0.5000	0.3333	1	0.5000	0.5000
Status of industry	0.5715	1	0.4553	0.3333	0.5715

Calculate the correlation coefficient of the suppliers in each index according to formula (3) and get the specific values, as shown in Table 3.

The later analysis is based on the given weight [15]: $\omega_j = (0.0793, 0.0582, 0.0663, 0.0470, 0.0657, 0.0690, 0.0839, 0.0394, 0.0491, 0.0696, 0.0804, 0.0570, 0.0470, 0.0841, 0.0470, 0.0570)$, The gray correlation values of suppliers obtained: (0.5230, 0.7569, 0.5765, 0.6225)

From the result, we can see that the second supplier is the best choice. The purchasing department should cooperate with the second supplier.

5 Conclusion

Construction supply chain management mode puts forward higher requirements to supplier's products, adaptability and sustainable development. The choice of suppliers relates to the competitiveness of the entire supply chain. The paper proposes the principles of the scientific establishment of supplier selection index system. And a specific evaluation index system is established. By comparing a variety of evaluation methods, the paper selects the gray relational analysis method based on gray theory. The gray relational analysis method is suitable for multi-criteria decision making problems. The gray relational analysis combines qualitative and quantitative methods together to exclude the subjective arbitrariness of the decision makers in the certain extent. Besides that, the method simplifies the complex decision-making problems with a small amount of calculation. In the last part of the paper, a numerical example is used to illustrate the rationality and feasibility of the method. The content of this paper provides a scientific basis for construction enterprises to select the proper supplier.

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Research on Mode of Commercial Cloud of Tianjin Binhai New Area

Da-tong Xu, Jiang Shen, and Xiao-qin Liang

Abstract This paper commences commercial cloud model research around the ideas of wisdom Binhai construction. Combined with the diversified social needs of the Binhai New Area, the facts of the rapid development of cloud computing technology commercial services evolution, history and commercial services, this article explains the urgency and necessity of the commercial cloud development and uncovers the support points of commercial cloud model development, in order to enhance the wisdom- Binhai economic development and governance strategic advantageous position and decision-making levels.

Keywords Cloud • Commercial • E-government

1 Background and Significance of the Implementation of the Project

1.1 Background and Necessity of the Project

Eric Schmidt proposed the concept of cloud computing firstly in "Cloud Computing: Web-Based Applications That Change the Way You Work and Collaborate

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Online" [1] in 2006. After, Amazon pioneered the elastic compute cloud service model (EC2) of small and medium-sized enterprises based on computing power of data center [2]. At this point, cloud computing service began in commercial activities. IBM proposed a new business concept of the "Smarter Earth", "Intelligent Business" in 2008. It make the cloud computing and smart technology fully applied to social economic activities, expanding the concept of the business model [3]. Cloud computing reached a new height during the IT evolution, promoting enterprise and social progress, bringing a new, more efficient, flexible, collaborative mode. The cloud-related commercial projects are becoming the focus of future development, enterprise growth performance and technology research difficulty of Google, Amazon, IBM and Apple-Creating a business miracle, and pre-effect is appearing. As cloud computing technology continues to mature, business model changes that it brings are emerging, appearing the operation mode of the business competitiveness, such as the Salesforce cloud computing business model (2008) [4], the Amazon elastic cloud model (2007) [2], Google Apps (2009) [5], cloud computing "software + services" model (2009) [6] and private cloud business model (2008) [7]. Meanwhile, cloud computing applications have begun to expand from the business field to the government field. With its good scalability and resource sharing, cloud computing forms the collaboration and interaction between business and government. In the United States, the e-government platform based on "cloud" achieved good effect in the practice of supporting production services. Currently, the pace of development of China's cloud computing is remarkable. "Cloud" building has been identified as the basic mode of "government investment, supplemented by enterprises building". The State Ministry of Industry, together with the Development and Reform Commission issued a "Notice abort doing a good job of the cloud computing service innovation development pilot demonstration work". The notice identified five cities, such as Beijing, as pilot cities for cloud computing application development, and developed a corresponding cloud computing center planning respectively. "China Cloud Computing White Paper" forecast that the size of China cloud computing applications market will expand to RMB 60.678 billion in 2012 and 80 % of the commercial operation services will be provided by the cloud computing in 5 years [8]. Driven by multiple factors such as advances in technology, market demand, policy-oriented, effective and efficient, cloud computing technology and its commercial application show a wide range of prospects and development space in our country.

As China's economic development "growth pole", Tianjin Binhai New Area becomes the country's most dynamic region and shows a strong comprehensive strength, radiation and driving effect. Its GDP in 2011 reached a total of RMB 620.69 billion. Building industry position of high-end manufacturing base in China, makes the Binhai New Area continue to attract the supply chain upstream and downstream enterprises to enter and station, attract high-end management and technology professionals to join and modern services to join. The good economic foundation, business and cultural environment make the Binhai New Area have hosted development of cloud computing technology and economic strength.

This year, the Binhai New Area proposed “wisdom coastal” plan. Taking the “Milky Way One” as supporting platform, this program has been initiated administration of work safety and health systems projects. From the endogenous demand perspective, facing the complex internal and external economic environment, fierce regional competition and the need for further development of its own, the Binhai New Area still has the Is unbalanced, incoordination contradictions in the development process, such as the contradiction between supporting services to be perfect and the demand for services of high-speed development, the difference contradiction between development model planning and the reality of development practice, the contradiction between existing government service policies and system design and future development planning. The introduction of the “commercial cloud model” will facilitate the integration of existing business resources of the Binhai New Area. It is conducive to build on strengths and economic development and business services coordination, business planning and business practices synergies and business services chain balance.

The nature of cloud computing is the efficient integration and utilization of resources. It is a cloud-based IT platform, based on huge cloud database and provides the necessary resources through the shortest path. First of all, these technical characteristics match the business services requirements of the Binhai New Area, that is to say in the mass of information and the complex organizational and information network environment, it can complete the business service resource allocation swiftly in the shortest possible time. Secondly, cloud computing can form an extensible IT framework. Accessing the full range of government effective resources, it helps Binhai New Area Commission of Commerce be effective to control government services on the overall layout. Thirdly, the commercial cloud model will provide a cloud resource sharing mechanism. It combines internal and external resources, and it can share the already existing mature government services platform, e-commerce platform for commercial cloud platform. It implements a broad G2B, G2C, C2G, G2G, B2G, and has been the development results as we used to.

1.2 Benefits and Effect of the Commercial Cloud

1. The commercial cloud is the service model innovation of Binhai New Area
   The business service practice of putting the cloud computing into Binhai new area Commission of Commerce, not only is the simply duplicated at the technical level, but also focus on the formation of innovative government services mode to match the cloud computing. Cloud-based commercial service model innovation should be reflected in three aspects: (1) Service Virtualization, “Virtual cloud” can make the ever-present cloud resources in everywhere service for the practical needs all the time. The commercial cloud platform constructed by virtualization loosely coupled model will be based on demand, dynamic release, spin-off,

the reconstruction of physical and virtual resources, without attention to the underlying resource deployment, simply access the cloud computing services, that is it can be integrated to configure a large number of resources to achieve real-time applications. This capability in response to the demand for business services is particularly important in the process of the rapid growth of the Binhai New Area residential population from 2.5 to 6 million in the next few years. (2) Service Differentiation, facing the complexity and heterogeneous group that demand for business services of the Binhai New Area, the commercial cloud achieves the demand – function mapping to meet the requirements of complex multi-level business services through the data excavation of cloud computing resource pool, the acquisition of dynamic fine-grained resource and the accurate perception, capture and analyze the preferences and regularity of demand. (3) Services Customized, Commercial cloud takes pulling supply chain mode as a demand-driven, takes the flexible scalable platform as the interface. Facing the uncertainty of external resources or the client's needs growth, commercial cloud can be done in real-time, personalized end-to-end business services.

2. The core of commercial cloud is the solution to the Binhai New Area commercial governance issues
   From the appearance point of view, cloud computing is a leading IT technology, but its essence is reflected in governance issues. Commercial cloud model that we proposed is planning and constructing on the government business service functions, and for the practical need of the Binhai New Area of business governance directly. Commercial cloud model has obvious advantages for solving the three types of government governance issues: (1) From the point of view of business environmental governance, it helps to standardize and optimize the financial environment for investment, production environment and social living environment. Its main features include efficient allocation of social and economic resources, services network layout, market-conflict coordination, rapid integration and access to information resources. (2) From the point of view of functions of government services, it will help improve the efficiency and accuracy of government services, improve service quality, and establish the image of the high-end government services. The main function of the level includes government commercial service model design, the organizational structure and terms of reference reengineering based on the commercial cloud, lean agile service process design, government service performance evaluation design, service innovation system construction and risk control system. (3) From the point of view of government decision-making, it is conducive to the promotion of administrative decision-making change from the management model to a service type, from the "top-down" individual decision-making path to the "top-down" and "bottom-up" consultative one, and the transformation of the nets decision-making path. The main function of the level includes the decision-making path design, the nets decision-making information acquisition and information fusion model planning, the improvement of decision nodes and process design.

3. The key of commercial cloud lies in broadening the chain structure of Binhai New Area Business Services from the dual dimension
   Binhai New Area Business service chain includes all aspects of meeting the target's needs that directly or indirectly involved in. Overall, the commercial service chain includes three plates-business services, investment and foreign trade. According to the actual situation, it starts the business services sector firstly, and set aside the interface of other two plates. Binhai New Area commercial service chain shows double-structured: Internal is the commercial services chain between government and government or between government departments (G2G), between government and business (G2B), between the Government and independent groups or individuals (G2C); External is the commercial service chain in different regions of domestic and abroad, different industries and business areas. Its key role is: (1) Scalable service boundary. Rapid deployment of resources and services virtualized and dynamic scalable expansion can be by "service chain cloud" mode. The mode has the ability to deal with the geometrically increasing resources that the Internet can't be integrated to achieve the dynamic of value-added services. (2) The multi-level chain management. It can simultaneously manage many value chains and related business processes. It makes the value chains in commercial ecological environment be together by many-to-many link. It integrated the services into service components that includes general services, modular choice services, customized services and other type, and with the external market changes quickly, service components combine, split and recombine. (3) Differentiated agile service. It quickly responds to the needs of clients and service-driven market. It gives great flexibility of business processes and demand-triggered. (4) Improving core competitiveness. Basing on their respective core competencies, serviced enterprises enhance the core competitiveness of enterprises through sharing the advantage resources; Through knowledge spillovers, they share resources fully and improve the core competitiveness of the region in the overall.

This research will achieve the targets of three levels:

1. From the level of commercial cloud framework model, this research studies commercial cloud frame mode operation mechanism from a strategic height using cloud computing technology and management theory, and it innovatively introduces virtual resource sharing mechanism, the aggregation effect, the design of integration ability, cloud computing technology into the business model innovation practice.
2. From the level of commercial cloud path demonstration system, through designing the commercial cloud system module and function, this research studies building Binhai New Area commercial resource pool and virtual network linking mode, and plans Binhai New Area commercial cloud service functions to improve commercial cloud framework planning system, using planning leverage to leverage the construction of Binhai New Area commercial.

3. From the level of commercial cloud management applications, through the design of cloud-based commercial services platform system facilities planning, this research practices new business management service model in commercial cloud management application, and builds a service-oriented government to improve the quality and efficiency of government services, and plays the leading role of the Tianjin economic growth.

2 The Main Content of the Research Work

2.1 Binhai New Area Commercial Cloud Design Background

1. National policy research
   Instructions of general secretary Hu Jintao
   Premier Wen Jiabao put forward five requirements of the development
   State Department documents
2. Research of Binhai New Area's "Twelve Five" business strategic planning
3. Binhai New Area's development achievements
4. Present situation analysis of Binhai New Area commercial activities
5. Analysis of the core competitiveness of the domestic related regional
6. The mode needs and preferences analysis of service targets

2.2 The Theory and Mechanism of Commercial Cloud

1. Relations theory based on the strategic behavior of government services
2. Virtual Knowledge Management
3. Advantage resource-oriented strategic behavior theory
4. Business Intelligence and core competence theory
5. Knowledge Spillovers and innovation diffusion theory
6. Entropy theory of service management

2.3 Thematic Studies of Domestic and Foreign-Related Cases

1. Development status and trends of cloud computing commercial model
2. Electronic Technology industry service model of Shenzhen and productive service mode of Pudong financial center

3. Development status and trends of the United States, the European e-government and their production services

2.4 The Theory and Mechanism of Binhai New Area Commercial Cloud Frame Design

1. The basic framework of the commercial cloud
2. The logical model of the commercial cloud
3. Organization and management model and system design
4. Analysis of Cloud service model
5. Model design of Elastic information
6. Agglomeration effects and integration capabilities Chain Design
7. Mechanism design of sharing virtual resource
8. Investment financing mode
9. Operation mechanism and strategy mode

2.5 Cloud Platform Development Framework Model and Its Key Technologies

1. The basic framework model of the commercial cloud platform planning
   The basic framework model of the commercial cloud platform planning is as shown in Fig. 1. It is divided into three levels from bottom to top: Infrastructure as a service layer (IaaS), Platform as a service Layer (PaaS) and Software as a service layer (SaaS). Each commercial cloud service can be a separate cloud and be used by end-users directly, and also can provide services basing on lower cloud services or supporting the upper cloud services.
   - Infrastructure as a service layer (IaaS)
   - Platform as a service layer (PaaS)
   - Software as a service layer (SaaS)
2. Key technologies of commercial cloud platform development
   - Resource pool technology
   - RFID technology
   - Scalable N-layers heterogeneous platform technology
3. Study of commercial cloud platform risk and security management
   - Information security framework
   - Cloud security risk analysis and control
   - Viable cloud security strategy model and its architecture

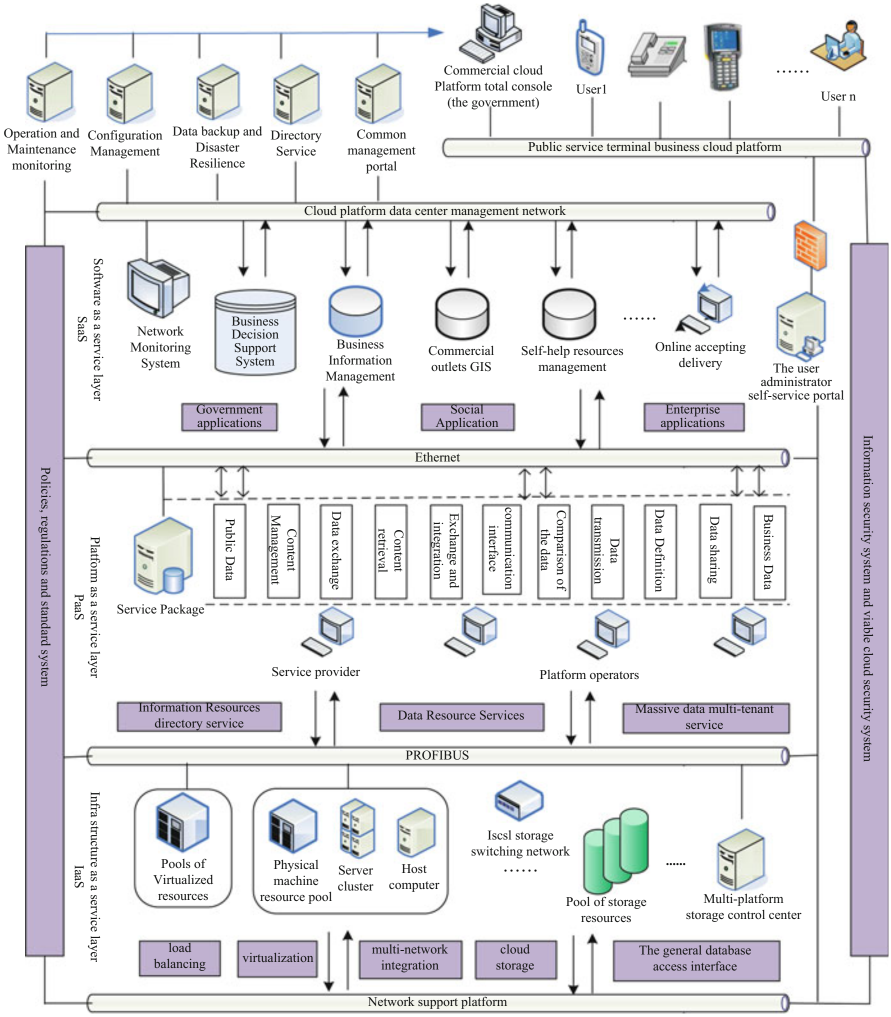

Fig. 1 Basic framework model of the commercial cloud platform planning

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Research on Path of the Construction of Ecological City Under Polycentric Governance – Taking Tianjin Eco-city as an Example

Ze-min Ji and Meng Shen

Abstract With the accelerating process of urbanization, Eco-cities have been coming from concept to practice. The process of construction and management in Eco-city is a Polycentric governance process, which different from traditional city. Tianjin Eco-City has been searching for how to construct and manage under the structure of the Polycentric governance, finding the path of constructing the Eco-city, and providing a reference for other areas.

Keywords Eco-city path analysis • Polycentric governance

As a reflection and fostering of the traditional urbanization movement of which the core is industrial civilization, Ecological city reflects the interaction and coordination of industrialization, urbanization and modern civilization, and it substantially adapts to the inner requirement of urban sustainable development, which marks the transition of city from traditional pattern of economic growth only to the comprehensive development pattern of organic fusion of economic, social and ecological development. As nature's ecological system is an organic multiple system, the construction and management of ecological city is not a one-dimension government action, but a polycentric governance mode with the interaction of a

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variety of power. This article takes the development and construction of Sino-Singapore Tianjin eco-city as an example to analyze the ecological city construction method in the framework of the multi-center governance.

1 The Concept and Practice of Ecological City

The concept of Eco-city was raised during the study of “man and the biosphere (MAB)” launched in the 1970s of last century by UNESCO, which got a global concern as soon as it was put forward. Current academic discussed more about the concept of eco-city, but there is no consistent definition. Famous scholars such as Yan Jingsong and Wang Rusong believe that eco-city is using principles of ecological economics and systems engineering methods within the carrying capacity of ecosystems to adjust production methods and consumption patterns, decision-making and management and transform the traditional economic model of construction and urban development [1]. Professor Huang Guangyu thinks that eco-city is the social-economic-natural sustainable developing, resident satisfied, economic effective, benign ecological cycling human community the construction of which applies ecological engineering, social engineering, systems engineering and other modern science and technology that is a comprehensive research of social – economic – natural compound ecosystem according to the principle of ecology [2]. Wang Faceng believes that ecological city is a kind of urban human settlements that can prompt the coexistence and coordinated development of urban population, natural harmonious, resources, society, economy and environment and efficiently use of substance, energy and information, established based on the modern ecology science theory by means of scientific regulation of ecosystem [3]. Summing up the above viewpoints, the author suggests that ecological city should be a kind of intensive human settlement that is a economic, social and natural coordination development, a effectively utilization of substance, energy and information, a sufficient fusion of technology, culture and landscape, which gives a full play to the potential of human and nature as well as physically and mentally healthy. The generalized ecological city should be a new cultural outlook based on a more profound understanding of the relation between man and nature and the new social relations with a coordination of economy, society and nature established in accordance with the principle of ecology, as well as a new way of production and life that means effectively using environmental resources to achieve sustainable development.

Concept and the practices of ecological city show that standard of judging whether a city is advanced have been gradually transformed from “only techno-enabled” into the “four dimensions-balance of the environment, resource, society and economy balance” [4]. Ecological city has three parts of connotation, namely the social ecology which means people should have consciousness of ecological consciousness and environmental values, life quality and health level, adapt to social progress and economic development; economic ecology that indicates through the sustainable development of the production, consumption, transportation, and the residence development mode to implement cleaner production and civilized consumption and promote the ecological industry and ecological engineering technology; ecological environment that refers to the development that depends on the conservation of nature and be in harmony with the environment carrying capacity of the natural environment and of which the evolution process obtains maximum protection, the utilization of natural resources and protect life support system is rational as well as the development and construction activities always stay within the environmental carrying capacity.

In particularly, ecological city has the following characteristics: (1) harmony. This not only reflects in the relationship between human and nature that means the coexistence and co-prosperity between human and nature, fusion between nature and the city, but also reflects in interpersonal relationship that ecological city is full of human kindness, culture atmosphere, mutual help, vigor and vitality. (2) High efficiency. Changing traditional "high energy-consuming and no cycling" operation mechanism of industrial city by improving the utilization rate of resources, physical distribution, and waste recycling, multi-level hierarchical use of the material, energy and adjusting coordination between different departments and industries through the symbiotic relationship. (3) Sustainability. Guided by the sustainable development, ecological city allocates time and space resources in different ways for rationality and will not promote the city "prosperity" temporarily due to the immediate interests like "plunder", and it is fair to meet the needs of modern people and future generations in terms of development and the environment, and will ensure the city's economic and social health, sustained and coordinated development. (4) Integrity. Ecological city not only pursues beautiful environment and its own prosperity, but also the balance among social, economic, and environmental benefits, attaches importance to economic development and ecological environment and the quality of life of residents, and pays more attention to seek development under the overall coordination of the new order. (5) Regional. As a unity of urban and rural, ecological city depends on the regional balance to achieve the balance between region and region by linking urban and rural areas to each other and restraining each other.

In recent years, more than 20 cities like Tianjin, Guangzhou, Shanghai, Ningbo, Kunming, Chengdu and so on successively put forward the construction of ecological city, and have carried on positive explorations. Throughout the urban construction practice of ecological city, constructing ecological city mainly starts from the social ecology, natural ecology and economic ecology, the content includes: (1) The urban life. This includes the capacity of a regional ecological infrastructure (such as light, heat, water, climate, soil, biology, etc.), ecological service function of the closed chain, exhaust degree of substance metabolism and hysteresis and ecological integration degree of time, space and amount of landscape. (2) The living environment. This emphasizes on community building in the ecological urban planning to create harmonious and beautiful living environment. (3) Ecological industry. Based on ecosystem carrying capacity, Ecological industry develops industries of efficient economic benefit and harmonious ecological function, by two or more than two coupling between production system, to realize multilevel utilization of matter and energy, high output and systematic development and sustainable use of resources and environment. (4) Social participation. "Low carbon is a kind of life style, is a set of habits of saving resources, for the average person, it is an attitude not ability" [4]. The ecological city construction particularly emphasizes on involvement of everyone, through publicizing ecological concepts and a variety of system design in-depth, in order to make the ecological urban construction goals be concrete actions in everyone's daily life.

2 Correspondence Between Multi-centre Governance Theory and the Ecological City Construction

Multi-center governance theory co-founded by the American scholar Elinor Ostrom and Vincent Ostrom couple. The theory put forward that between extremely two different governance methods namely privatization and nationalization, there are many other possible ways of governance to run efficiently. And compared with government imposed by the regulations and pure way of marketization, the community can better manage public resources alone. Its core viewpoints include:

1. The multi-center means more producers of public goods and more processing principal of public affairs. "Multi-center governance is trying to keep the public affairs publicity, at the same time through a variety of participants with similar properties and characteristics of similar objects, to set up a competition or on prospective competition in the traditional monopoly of public affairs by single department" [5]. And realize the self-discipline of individual producers, costs reducing, quality improving and response increasing through the competition between main production bodies.
2. Multi-center governance means the participation of the government and market and application of a variety of management methods. Multi-center governance mode jumps out of the limitations of traditional either-or thinking, argues that the government and the market are both the main body of public transaction processing, and two different means and mechanisms of the public goods configuration, and in dealing with public affairs, should not only fully guarantee the advantage of centralized government publicity, but also take advantage of strong response and high efficiency of the market, integrate the advantages of two main bodies and means, to provide a new paradigm of public affairs governance which features cooperative work.
3. Multi-center governance requires the government to transform their roles and tasks. Multi-center governance is opposed to both the government's monopoly and the so-called privatization. Government transforms their role from out in the field of public affairs does not mean that the government and the assignment of responsibility instead of government, the responsibility and management changes. The government of multi-center governance is no longer a single subject, but just one of the main bodies. The government's management style changes from previous direct management to indirect management. In multi-center governance, the government plays the role more like a mediator, draws

up the macro framework of polycentric governance and the participants' behavior rule, and at the same time uses a variety of means such as economic, legal, policy to provide basis and convenience for public goods and public affairs.

Multi-center governance theory provided important thought origin and its core connotation for the thoughts of governance formed in the early 1990s. According to the theory of governance, the government is not the only power center, a variety of social and private institutions as long as which get the public recognition, can be different level centers of social power. Multi-center governance theory helps answer what system can promote the effective sharing of public resources and the sustainable development of society.

Construction and management of ecological city in essence has many aspects of conjunction in common with multi-center governance theory, and ecological city is to make urban governance from "single-center" to "multi-center". In modern urban society, there are many of fields that simply cannot intervened by government behavior, such as businesses, communities and clubs, and private organizations like professional associations, which are not within the scope of government restrictions. In order to build ecological city, we should take these groups and resources to effectively use and integrate to make it play a role in the urban construction and management and form a network of independent.

The necessity and feasibility of Multi-center governance is demonstrated in the city to of independent governance. It broke the traditional single-center governing mode and formed a governance network composed of multiple power centers, to undertake public management and public service responsibilities within the scope of a particular city. Compared with the traditional single-center city governance, the advantages of multi-center governing of city are as follows: (1) The multivariate governance bodies. Urban governance body can be either public institutions or a private institution, and also can be cooperation among private and public institutions. Urban governance is not just a government public power center, in addition to the government, society and some voluntary or belongs to the so-called third sector nongovernmental organizations and other social groups, they are responsible for maintaining order, and participate in the political, economic, and urban affairs management and regulation. (2) Power of Management is not monopoly. Whether they are government officials, the general public, entrepreneur, or the government and other organizations, they enjoyed only limited and relatively independent decision-making power. Each subject is allowed to have equal decision-making power and the freedom of independent decision in city affairs within the scope of the law. (3) Democratic governance. Multicenter governance emphasizes the decision center down to institutionalization, negotiation, moderate competition for governance, based on independent for governance, governance range but can small, diversity of transaction. Multiplicity of the governance bodies provides the opportunity to express different organizations and public interest preference, and gives play to the important role of urban public affairs management in the process of competition and cooperation, as well as conflict and harmony.

3 The Multi-center Governance Practices in Tianjin China-Singapore Eco-city Construction

Sino-Singapore Tianjin eco-city is a new major collaborative project between the two governments, and is also the cooperative ecological city by two countries in the world. According to the new governments requirements, the eco-city's location should highlight in significance of eco-city construction under resource constraints condition, conform to the basic national policy that protects the cultivated land, do not take up the cultivated land. Due to regional resources relative shortage, the historical pollution governance combined with a new ecological city construction, change the way of realization of urban development, to provide demonstration for the similar area. Eco-city located in September 2007, north of Tianjin Binhai new area, where there is land salinization, lack of fresh water, and serious pollution, can highlight the significance of construction of ecological city. In September 2008, the construction of the new eco-city officially started.

Sino-Singapore eco-city has a planned area of 30 km^2, population of 350,000, and basic construction of which will be finished in the next 10 years. Its development orientation is: committed to build a new "resource-saving, environment friendly, economic promoting and social harmony" city, with a comprehensive ecological environmental protection, circular economy technological innovation and application promotion platform such as energy conservation and emission reduction, green building, as well as the national ecological environmental protection training promotion center, modern ecotype high-tech industry base, to participate in international communication show window, ecological environment construction and to be a "resource saving and environment-friendly" livable new town. Eco-city construction target is identified as "Sanhe and SanNeng", namely, human harmony, people and economic activities in harmony, people and environment in harmony, being able to carry out, copy, and promote and a model for the sustainable development of other cities in China [6]. In urban construction and management, the new eco-city embodies the connotation of multi-center governance theory well.

1. The governance framework led by the government. In the construction of eco-city, a comprehensive cooperation has been carried out in city planning, environmental protection, resource saving, circular economy and ecological construction, renewable energy utilization, water reuse, sustainable development and promote social harmony and so on to establish new mutual effective mechanism for promoting the development of industry. To support and strengthen the guiding of eco-city construction, the deputy prime minister level of eco-city joint coordinating council was formed between the two countries, which is responsible for all significant matters on the coordination of development and construction. Led by department of housing and urban-rural development in China and development department of Singapore, the China-Singapore joint committee discussed about relevant specific studies to solve the related problems in development and construction. We formulate Sino-Singapore Tianjin eco-city index system with a total of 26 indicators, including 22 controlling indexes on

three aspects of ecological environment health, social harmony and progress, economy booming and four leading indicators on the natural ecology coordination, regional integration, social and cultural coordination, regional economy coordination, etc., as quantitative standard for management of the construction of the eco-city development [7]. And they devote to building efficient administrative environment, standardizing administrative behavior, reducing the examination and approval links, and improving administrative efficiency.

2. Formation of cooperation mechanism on the basis of separating government and enterprise. According to the requirements of separate government functions from enterprise management and market-oriented operation, the government of Tianjin established the eco-city management committee, which is on behalf of the government to execute administrative functions. China set up an investment company, which is responsible for land consolidation, ecological environment construction and public welfare of public facilities construction, and a joint venture with Singapore enterprise, which is responsible for the commercial and industrial construction project and investment. And meanwhile it devoted to improving the capacity of public services, improve the infrastructure construction, expanding service content, and building new mechanism conducive to the healthy and harmonious development of city.
3. Adhere to market-oriented operation and form the market mechanism. Play an active role of market mechanism in elements of the allocation of resources, and promote the socialization, marketization and industrialization of eco-city construction. By granting business franchise and lengthening the maturity of project management, and adopting BOT, DBO market-oriented means, we can promote energy, municipal, environmental protection and sanitation facilities construction and operation of market-oriented operation, socialization and specialization service. Establish a diversified investment and financing mechanism. Eco-city management committee established special fiscal funds to ensure the investment of the ecological environment protection and construction, supported enterprises to issue bonds and listed financing, explored the implementation of emissions trading, establishing regional environmental compensation mechanism, and encouraged all kinds of investment main body participation in eco-city project construction.
4. Combine government management and public participation. "In multi-center governance, different government units have very different nature of exercising power, some of which have the power of the general purpose provides extensive public service to a community, while the authority of others is a special purpose which can only provide such as irrigation or road system operation and maintenance of such services" [8]. Construction of center eco-city utilizes diversified power and government units, in order to solve the public governance issues in the construction of different range.

One is the innovation decision-making supervision mechanism. According to the scientific and democratic goal to perfect the comprehensive decision-making mechanism, guarantee the citizens to participate in major projects, development planning and policy-making rights, and establish a reasonable and effective public participation in decision-making mechanism. Gradually establish an evaluation system to the implementation of the whole society, strictly enforce the environmental impact assessment of development project involving important resources; establish information disclosure system, society and the media supervision system, and perfect regulation mechanism. Second, innovate the mechanism of community management and service and strengthen the public service and the safeguard function. Established by units government-led, residents-participated basic management organizations of community committee in community, make the people directly involve in management of basic public affairs and public welfare undertakings according to law, to carry out self-management, self-service, self-education and self-supervision to realize the effective cohesion and benign interaction between the government administrative management and grass-roots autonomy. Thirdly, explore cross-regional cooperation mechanism. Take the regional atmosphere, watershed area water environment, ecology, energy supply, solid waste disposal as the key point, focus on inter-regional ecological protection, pollution control and management; Promote regional industry linkage development, form the information exchange, facilities linked, environmental and industrial interacted, achievement-shared mode of cooperation.

4 Method of Ecological City Construction Under Multi-center Pattern

At present, the entire world is now in a critical period of urbanization. The global urbanization level has been raised from less than 30 % in 1950 to 50 %. Today, the massive influx of rural population city, energy consumption behavior has changed dramatically. Member of the French academy of sciences Guy Laval, estimates that by 2030 more than the world's population will reach 80 billion and urban energy consumption will be up to 73 % [9]. Since China's reform and sustaining the faster speed of urbanization, the urbanization level increased from 17.92 % in 1978 to 51.27 % in 2012. Attending to build ecological city has become the objective need to cope with the rapid urbanization [10]. To make the ecological city planning and construction into reality, it's necessary to transform government single-center governance and form the government, enterprises, society and public coordinate multi-agency management pattern.

1. On the government level: planning and policy coordination. In traditional urban governance structure, the existing policy and system determines that the government functional departments in most cases only consider the function in the field of work content, which result in the lack of demand for ecological city construction as a whole. In the process of planning and construction of ecological city, in addition to ecological technical updates, more challenges exist in the solution of the political, social and cultural problems, which requires

overall consideration to these issues in the process of ecological city planning, therefore, the ecological city planning and construction of the first needs an agreement between the governments on the values of the concept of ecological city. At the same time, the government should strengthen the coordination between policies, promote the coordination of various functional departments, make the government's functional departments for the construction of ecological city synchronous know unity, practice, and from individual to the global, and form a mechanism of coordination and linkage between the various functional departments.

2. On corporate level: to carry out the social responsibility and technology practice. Enterprise, as a representative of the city's social citizens for the sustainable development of resources and the environment, has the unshakable responsibility and obligation. In the process of the construction of ecological city, the enterprise can implement government policies on the one hand, to take technical innovation practices, and complete various projects in the urban development and guarantee the low carbon operation; On the other hand, they can reduce production activity which may cause to the environment pollution on each link through technology innovation, in order to fulfill social responsibilities of protecting resources and environment, and achieve sustainable development. In addition, enterprises can also be active in a variety of business related to public welfare, environmental protection, construct environmental protection facilities together with the community, purify the environment, and protect the interests of the community and other citizens.
3. On the community level: set up citizen autonomy and participation of platform. Community occupies the important position in urban governance structure and the key link, is the resident community of social life, people's commune, and the government administration and social self-management administration according to law, the government and residents autonomy of bridge and link in accordance with the law. Through policy support, multi-channel financing, resource sharing, do something to help build a new modern community in many ways, such as improving community infrastructure conditions and services, in the community residents of broad participation mechanism, and strive to build a new modern community where there is orderly management, perfect service, a beautiful convenient environment, good public security, and harmonious interpersonal relationship. All kinds of associations, industry associations, professional organizations, intermediaries such as non-profit social organization, are effective ways of citizen participation in urban governance. In innovation mode of urban governance, we should especially develop all kinds of social organizations, encourage the innovation in social service work in their respective field, effectively resolve social contradictions, establish urban citizen, social organization and transmit an order from above between government departments, private information exchange mechanism, urban governance in policy-making, implementation, to supervise the whole process of participation, and give full play of the role of residents and social organizations in urban management.

4. On Public level: to promote low carbon behavior change and development. Citizens as the participants of public users and construction, plays an important role in accomplishing the urban development goals. In the process of ecological city construction, public behavior transformation is an important aspect, which includes under the guidance of moral values, people's life style, consumption way, behavior way shifting to a low-carbon and sustainable health. Low carbonization of public travel way, consumption way and living ways, will have great influence on social and public life of low carbon, to mobilize all social forces, give full play to the public enthusiasm, initiative and creativity in the ecological urban construction, promote establish energy conservation idea, encourage people to use public transport more, and more consumption of low carbon products, guide the choose intensive living in public housing, and make a lower carbon life content into the ecological city society.

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Using Simulation Game and Enhancement to Overcome Two Obstacles That Block the Introduction of SDBR to Production Management Society

Chia-Ling Huang, S.Y. Chen, and Rong-Kwei Li

Abstract Since 2001, the Simplified Drum-Buffer-Rope (SDBR) has received considerable attention. Hundreds of successful SDBR cases have achieved highly reliable due date performance (DDP) with short production lead-time (PLT) and minimum WIP. However, two obstacles have remained, blocking the introduction of SDBR to production management society. The first one is from production managers, who have been less than confident that DDP and PLT can be significantly improved by simply changing the way to manage production (SDBR way). The second is from SDBR itself meaning SDBR application makes an assumption – the total touch time is very small comparing to the current production lead time. However, from our study and experiences of implementing SDBR in local companies, we found out there are such environments where the total touch time is relatively large comparing to their production lead time. In this study, a simulation game and enhancement of SDBR were developed and tested to overcome both obstacles.

Keywords Production management • Simplified drum-buffer-rope • Theory of constraints

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1 Introduction

Although marketing promises on-time delivery to its customer for every delivery, but very poor DDP performance and long PLT is almost an epidemic for the make to order (MTO) manufacturing industry. In fact, numerous academic research papers on improving DDP and PLT have been published. Some studies have focused on investigating how to determine right dispatching rules (working priorities) for different production environments [1–5], others concentrated on rules for controlling order release [6–10] and [11–16] dealing with bottleneck starvation issues. Previous literatures have demonstrated that DDP and PLT can be improved through effective management of order release, working priorities, and bottleneck management. Despite the academic researches, business also employs numerous approaches developed by industrial practitioners including JIT (Just in Time), advanced production scheduling system (APS), and theory of constraints (TOC) [17, 18]. These efforts are all aimed at improving DDP and PLT. TOC SDBR developed by [19] is one of the best known methods of improving DDP and PLT.

Previously, hundreds of accounts of successful SDBR implementations [20] have been reported, all claiming that it are possible to rapidly achieve highly reliable DDP and short PLT. Despite hundreds of accounts of successful SDBR implementations, the introduction of SDBR to production management society still encounters two obstacles. The first one is from production management practitioners, who have been less than confident that DDP and PLT can be significantly improved by simply changing the way to manage production. The second is from SDBR itself which an application makes an assumption. The assumption of SDBR application is that the total touch time is very small ($<10\ \%$) comparing to the current production lead time. However, there is an environment where the total touch time is relatively large ($>20\ \%$) comparing to their production lead time. We call this environment "a high touch time production environment."

Concerning the first obstacle, a simulation game is developed to demonstrate that simply changing the way to manage production (or SDBR way) will significantly improve the DDP and PLT. Concerning the second obstacle, an integration of buffer management method of CCPM (Critical Chain Project Management) [21] to enhance SDBR is developed. We name this new way of applying SDBR to high touch time production environments as HTT-SDBR. An IC assembly plant is applied to test the feasibility.

2 Using Simulation to Overcome the First Obstacle

2.1 Root Cause to Poor Production Performance

Concerning the first obstacle, we asked two questions of local managers. The first is: why is it difficult to manage production? Eighty-five percents of reasons wrote by them can be summarized as excessive variability, such as machine breakdown,

Table 1 Contract list

ID	Name	Start	Stop	Type	Supply	Prod.	Qty.	Price
1	ABC	02/02/98	01/15/00	Monthly	–	A2	60	595
2	ABC	02/16/98	02/01/00	Monthly	–	A1	77	533
						A2	77	588
3	TSC	02/23/98	01/01/00	Monthly	–	A1	85	556
4	DEF	05/11/98	03/01/99	Monthly	–	A1	75	533

quality issues, demand changes, material shortages, unreliable processes and so on. Reducing variability thus has become the focus of improvement efforts, with programs such as Lean and Six Sigma becoming the norm. Unfortunately, the second question (if they have adopted Lean and Six Sigma programs, was the DDP improved significantly?) found that 80 % of the answers, their DDP remains a major issue, only 20 % of the answers said their DDP did improve but with a long time effort.

If variability is the main reason and improvement programs for reducing variability were also initiated, DDP and PLT should be significantly improved. However, reality is that it is not improved (or improved slowly). According to our learning and experiences of SDBR implementations, variability appears to be just one of the major causes that causes poor DDP and PLT. The other cause is our current mode of managing production which is designed with erroneous paradigms (or policies) such as: a resources standing idle is a major waste, efficiencies are the best guide of performance and profitability, lead time is a given, reducing set up reduces cost, process batch equals to transfer batch, everybody needs to be an expeditor, flow depends mainly on physical layout, etc. Which one is correct? Since it is impossible to test in reality, a job shop simulation game was designed and three simulation runs were performed to identify the correct root cause and to be improved first.

2.2 Job Shop Simulation System Design

The designed job shop plant was originally developed by [19]. It is a simple plant that produces only two standard products. The plant has to deliver four shipments every month based on the contract delivery (Table 1). Figure 1 illustrates the routings of the products. Flow is left to right and at the far left are the raw materials (only three types of raw material, Y1, Z1 and Z2). The yellow boxes are the production steps. In each, the production step appears at the top, then the work center (five work centers, M1, M2, M3, AS and PK, each work center with one machine only and with about 8 % breakdown rate) and at the bottom of the box is the net processing time of one piece. Raw material cost for A1 is \$350 and A2 is \$400. Operation cost for a year is about \$800,000.

Table 2 shows the current designed production policies. The minimum production batch is set at 100 pieces. This means if 60 units of A2 are needed to fill a

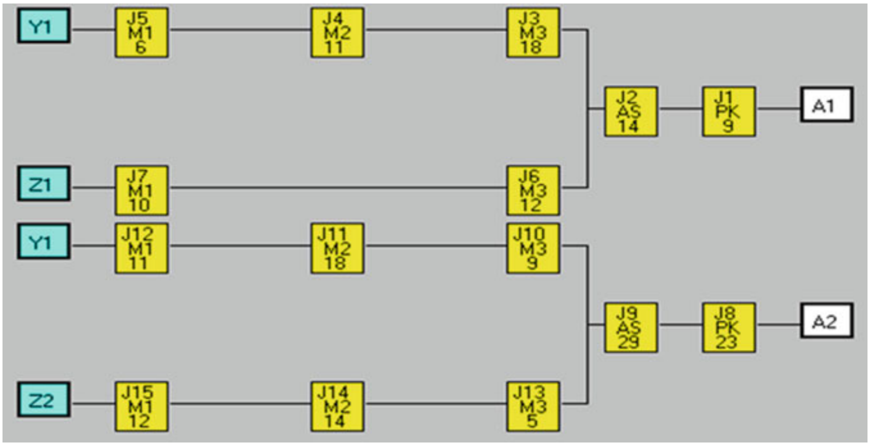

Fig. 1 Product routing

Table 2 Production policy

Production policy	Current policy	First run	Second run	Third run
Min. production batch size:	100	100	Work order	Work order
RM release policy;	MRP	MRP	MRP	MRP
Default MRP LT	7 Days	7 Days	7 Days	5 Days
WC policy:				
Dispatch:	Save setup	Save setup	EDD	EDD
WO acceptance:	Complete WO	Complete WO	Partial WO	Partial WO

contracted delivery, the system issues a new work order for 100 units of A2. The first 60 will be applied to the contract work order. The remaining 40 are available (finished stock) to commit to the later order. The material release policy used is MRP (material requirement planning). Once a work order is created, the materials are released to the production floor as scheduled by the MRP system. The MRP lead time is 7 days, meaning that each step in the process for each product has 7 days to be completed (5 steps for each product meaning 35 days production lead time is given). There are two types of work center policy; the dispatch policy and the work order acceptance. The former is set to setup saving meaning choose the work order that needs the same production operation so no setup is needed and the latter is set not allowed to start a work order that is incomplete (transfer batch equals to production batch).

The initial performance of the plant is not bad; the plant had $2,256,282 revenue and $85,000 profit last year (Table 3). These are decent financial results. However, it only delivered products 65 % on time last year. The DDP was so bad that two of its most lucrative contracts were not reviewed by customers last year. So profit of this year is sure to take a hit (decrease to about $27,000). Fifty production managers from local companies were invited to run this simulation, their main objective is to improve the DDP/PLT within half year with cost as low as possible.

Table 3 Experimental results

	Current	1st run	2nd run	3rd run
Sales	$2,256,282	$1,015,678	$1,255,512	$1,255,512
Profit	$85,285	$585	$26,131	$26,131
DDP	65 %	70 %	98 %	98 %
PLT	250 h	250 h	250 h	170 h

2.3 Simulation Runs

The participators were asked to run the simulation for three runs. The first run, don't change any current policies, but can manually override them when necessary. There are two ways to override: one is manually break the work order completion policy and the other is to add an additional shift. However, additional cost is necessary. Use the first run to observe which policy is most damaging. The second run is to change the production policies as shown in Table 2. The first two runs demonstrate how DDP can be improved by just changing the erroneous policies. The third run is to demonstrate how production lead time can be improved by changing the raw material release policy. The experimental processes are as follows: (1) Explaining the simulation game. (2) Explaining run one and performing trial run for process familiarization. (3) Running simulation run one. (4) Analyzing and discussing the results of run one. (5) Explaining the new policies and playing run two. (6) Analyzing and discussing the results of run two. (7) Explaining and playing run three. (8) Analyzing and comparing the results of the three runs. The experiment takes approximately 6 h to complete.

2.4 Analysis of the Results

Table 3 lists the experimental results based on the average of the 50 participators. 2/3 of the participators of first run are not good. However, even under the older policies 1/3 of the participators are possible to achieve an acceptable performance based on their intuition and capability to "look forward in time" and actually break the most pressing policies. But this gave them heavy burden. So, what designed policies in the case are truly flawed?

The participators identified both the fixed batch policy and production batch equals to transfer batch are flaw. The former causes difficulty in identifying the parts to be expedited, too many batches to be split, excess capacity not easily to be seen and calls for stealing and partial process. The later causes long PLT. So we ask the participators to change several policies and ran it again. The policies we changed are: (1) No batching – every production order exactly fits a specific customer order. (2) Allow partial work order meaning lets several work centers work on the same order. (3) Good priority mechanism (EDD (early due date first) instead of setup saving) to guide the execution. The results considerably better. The participators noticed that there is still some DDP pressure in the first month of the simulation run, since the plant still had orders large batch at the first month. As long as the system was flushed of unnecessary WIP, the flow became smooth and fast.

Although the DDP and profitability of second run are considerably better than the first run, the production lead time was no significantly improved. Can we further improve it? One of the erroneous paradigms mentioned in section one is that lead time is given. In this simulation, lead time is given by the default MRP lead time – 7 days. Since the touch time (theoretical processing time) of the products comparing to its current production lead time is very small (10–250 h). According to SDBR, we can cut the production lead significantly by chocking the material release as long as without creating starvation for the bottleneck machine. So we ask the participators to change the MRP lead time to 5 days which means release material only 25 days before delivery and run the third run. The results show that the DDP and profitability is the same while the production lead time is significantly reduced.

3 SDBR Enhancement to Overcome Second Obstacle

3.1 High Touch Time Production Environment

SDBR assumes that the total touch time is very small (<10 %) comparing to the current lead time. Figure 2a shows an example of the normal distribution of touch time across the PLT of a work order. Figure 2b presents the accumulation of touch time vs. PLT. Looking at the accumulated touch time, it is clear that the total touch time is only a fraction of the PLT. In such environments, SDBR suggests the production buffers are set to 50 % of the existing PLT; the reliable PLT (R-PLT) is equal to the length of the production buffer (Fig. 2c). This assumption is valid for many environments if not most typical production environments (the simulation game of Sect. 2 is the example). But, how about if an environment where the total touch time is relatively large (>20 %) comparing to their PLT (for example; IC manufacturing environments, shoe or garment sample manufacturing shops, etc.). This environment is called a “high touch time production environment” (Fig. 2d, e). In this environment, if we still apply SDBR, we found out it not only create negative effects such as not getting warning on time and accepting wrong messages, but also not be acceptable by production managers with this environment.

3.2 Buffer Management Methods of SDBR and CCPM

Buffer management is a control and warning mechanism technique. The objectives of buffer management are to check whether the DDP is threatened and to validate whether the buffer used adequately protects the system performance. The buffer

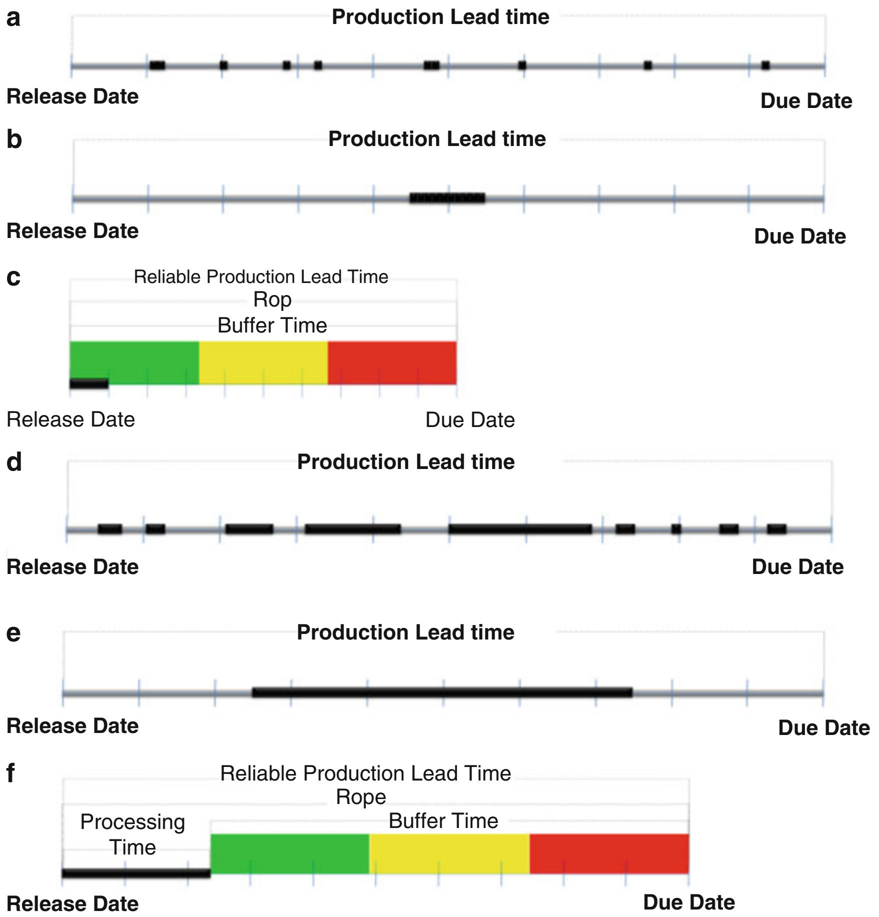

Fig. 2 Touch time vs. production lead time

in SDBR is a liberal estimation of the lead time from gaiting operation until completion. Hence, the buffer contains not just the variation and queue, but also the net touch time itself. SDBR buffer is divided into three, usually equal, zones. The last third of the buffer is the red zone (the emergency zone). The middle zone is called the yellow zone (warning) and the upper zone is green (safe). The red zone is usually >66 % and the yellow is between 33 and 66 % (Fig. 3a) [20].

The buffer in CCPM method is somewhat different. There are two different types of buffer; project buffer and feeding buffer. The project buffer is placed between the end of the last critical chain task and the due date of the project (Fig. 3b) [20]. It protects the project due date from variations and delays that occur on the critical chain. The feeding buffer placed between the end of non-critical chain tasks and the beginning of the critical chain task that it directly feeds. It protects

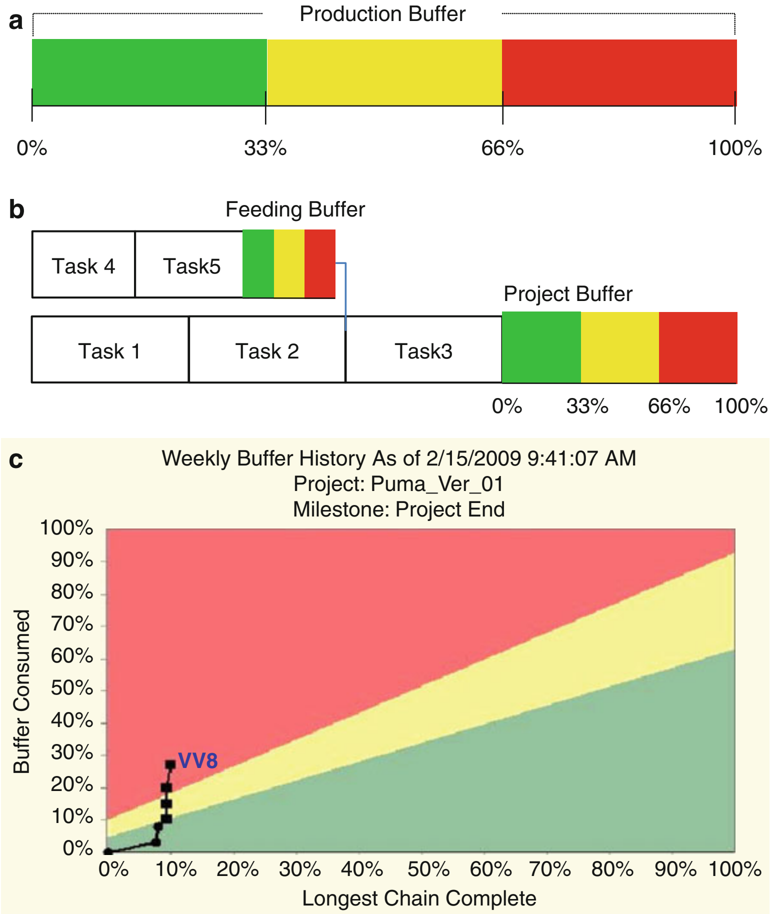

Fig. 3 Buffer management of SDBR vs. CCPM's

the critical chain from variations and delays from margining non-critical chain paths. Figure 3c illustrates a fever chart buffer management method used by the CCPM [21]. The vertical axis is percent buffer consumption; the horizontal axis is the percent completed. The regions defined by the top, middle, and bottom areas on the fever chart indicate whether the project is in trouble. Same as the SDBR buffer status, the bottom "green" zone means the project looks likely to make its commitment date; "yellow" means it is at risk and the top "red" zone means that without intervention it looks unlikely to make its commitment date. Figure 3c shows that the project is on red zone, and recover action is needed.

3.3 Apply CCPM Buffer Management to Enhance SDBR Application in High Touch Time Environment

The assumption of applying CCPM is its task time relative to project time is high. Therefore, when the touch time is a significant portion of PLT (e.g. >20 %), CCPM buffer method can be adopted. The production buffer therefore, is set to 50 % of the existing production lead times less the assumed touch time; The R-PLT equals to the production buffer plus the assumed touch time (Fig. 2f). In this environment, production buffer is separated from touch time and put at the end of the last operation. Therefore, the buffer penetration will be relative to the progress in completing the work just as in CCPM.

Relying on the accuracy of the production routings to differentiate exactly the difference between touch time and buffer time is unnecessary, and drives a tendency to spend exorbitant time and effort on improving data accuracy, at the expense of improving flow. It is sufficient to identify a few (3–5) key control points in the process and set green, yellow and red priority status based on percent of R-PLT passed when each of the key control point has been completed.

3.4 Case Study – An IC Assembly Company

The case company is an IC assembly company; focus on communication chip and LCD control chip assembly and testing. Its total revenue for 2010 was about 100 million US dollars. The company operates purely in a MTO environment. The data show that the total given standard process time (or current production lead time) is 192 h (8 days) and the total touch time is 84 h (3.5 days). The ratio of total processing time to touch time is about 2.3 times, it is a typical high touch time production environment. Their due date performance of 2009 and second quarter of 2010 was quite poor, average delay is almost >40 %. This pushes them to seek method to improve their due date performance.

Since the ratio of the total processing time (or current production lead time) to touch time of the case company is about 2.3 times, the current production lead time is taken as the R-PLT, therefore, the production buffer for the case company is 4.5 days (8 days minus touch time 3.5 days) and it will be put on the end of the last stage of the process.

Table 4 is the constructed fever chart which shows that if the order progress is normal, the color of the order at each stage at each check time should be yellow or green. If the color is red expedite is necessary. If the color is black meaning the order will be delayed, informing customer is necessary. For example, if an order was released and today is T + 0.5, normally the order should be at the stage between IQC stage and Wafer Saw (yellow or green zones). If the order is still at the stage of Trans & Rev, meaning the order has problem (9 % buffer consumption), follow

Table 4 Constructed fever chart

Stage		Transp. receiv.	IQC	Wafer grinding	Wafer saw	Die attach	Epoxy cure	Wine bond	Optical inspec.	Molding	PMC	Dejunk trim	Plating	Marking	Form singular	Final insp.	Packing shipping
Touch time		0.21	0.04	0.17	0.16	0.50	0.09	1.00	0.08	0.25	0.33	0.09	0.08	0.08	0.09	0.08	0.25
Acc. touch		0.21	0.25	0.42	0.58	1.08	1.17	2.17	2.25	2.50	2.83	2.92	3.00	3.08	3.17	3.25	3.50
Completion rate		3 %	7 %	10 %	14 %	24 %	32 %	48 %	63 %	68 %	76 %	82 %	84 %	87 %	89 %	92 %	96 %
Buffer consumed (%) at check point	0.5	9 %	6 %	4 %	0 %	−7 %	−14 %	−26 %	−38 %	−42 %	−48 %	−53 %	−55 %	−56 %	−58 %	−60 %	−64 %
	1.5	31 %	28 %	26 %	22 %	15 %	8 %	−4 %	−16 %	−19 %	−26 %	−31 %	−32 %	−34 %	−36 %	−38 %	−42 %
	2.5	53 %	50 %	48 %	44 %	37 %	31 %	19 %	6 %	3 %	−4 %	−8 %	−10 %	−12 %	−14 %	−16 %	−19 %
	3.5	75 %	73 %	70 %	67 %	59 %	53 %	41 %	29 %	25 %	19 %	14 %	12 %	10 %	8 %	7 %	3 %
	4.5	98 %	95 %	93 %	89 %	81 %	75 %	63 %	51 %	47 %	41 %	36 %	34 %	32 %	30 %	29 %	25 %
	5.5	120 %	117 %	115 %	111 %	104 %	97 %	85 %	73 %	69 %	63 %	58 %	57 %	55 %	53 %	51 %	47 %
	6.5	142 %	139 %	137 %	133 %	126 %	119 %	107 %	95 %	92 %	85 %	80 %	79 %	77 %	75 %	73 %	69 %
	7.5	164 %	162 %	159 %	156 %	148 %	142 %	130 %	118 %	114 %	107 %	103%	101 %	99 %	97 %	95 %	92 %
	8.5	187 %	184 %	181 %	178 %	170 %	164 %	152 %	140 %	136 %	130 %	125 %	123 %	121 %	119 %	118 %	114 %

Table 5 A comparison reports

	季度																	
資料	2007-1Q	2007-2Q	2007-Q3	2007-Q4	2008-Q1	2008-Q2	2008-Q3	2008-Q4	2009-Q1	2009-Q2	2009-Q3	2009-Q4	2010-Q1	2010-Q2	平均	2010-Q3	2010-Q4	平均
計數/工單	6,500	3,574	4,357	3,910	4,202	5,099	4,300	2,748	3,649	5,712	6,727	6,164	6,385	6,506	4,988	4,710	5,503	5,107
平均值/加工天數	7.59	7.58	8.42	7.23	7.67	7.44	7.56	7.03	7.75	7.34	8.11	7.29	8.14	7.53	7.62	6.53	6.51	6.52
最小值/加工天數	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
最大值/加工天數	16	16	18	17	18	18	18	20	18	20	18	18	18	19	18	16	16	16
標準差/加工天數	2.21	1.96	2.20	2.00	2.04	1.90	2.02	1.91	2.50	2.08	2.10	1.81	2.21	2.13	2.07	1.51	1.18	1.35
加總/Delay_All	1,740	1,064	1,988	881	1,097	1,414	1,101	504	1,263	2,677	3,498	2,179	3,419	2,639	1,819	563	363	463
加總/Delay=1	832	513	704	417	463	655	507	254	600	956	1,136	1,086	1,342	1,181	760	161	206	184
加總/Delay=2	438	277	556	239	300	391	257	134	307	650	923	561	842	588	462	265	117	191
加總/Delay>2	470	274	728	225	334	368	337	116	356	1,071	1,439	532	1,235	870	597	137	40	89
比例/Delay_All	26.8 %	29.8 %	45.6 %	22.5 %	26.1 %	27.7 %	25.6 %	18.3 %	34.6 %	46.9 %	52.0 %	35.4 %	53.5 %	40.6 %	34.7 %	12.0 %	6.6 %	9.3 %
比例/Delay=1	12.8 %	14.4 %	16.2 %	10.7 %	11.0 %	12.8 %	11.8 %	9.2 %	16.4 %	16.7 %	16.9 %	17.6 %	21.0 %	18.2 %	14.7 %	3.4 %	3.7 %	3.6 %
比例/Delay=2	6.7 %	7.8 %	12.8 %	6.1 %	7.1 %	7.7 %	6.0 %	4.9 %	8.4 %	11.4 %	13.7 %	9.1 %	13.2 %	9.0 %	8.8 %	5.6 %	2.1 %	3.9 %
比例/Delay>2	7.2 %	7.7 %	16.7 %	5.8 %	7.9 %	7.2 %	7.8 %	4.2 %	9.8 %	18.8 %	21.4 %	8.6 %	19.3 %	13.4 %	11.1 %	2.9 %	0.7 %	1.8 %

up action is needed. If today is T + 4.5 and the order is still at the stage of Trans & Rev, the order will be delayed and the customer should be informed and new deliver date should be reset.

Table 5 shows the comparison reports before July and after July of 2010. Before July, the average production lead time was 7.62 days, standard deviation is 2.07 days. After the implementation of HTT-SDBR, the average production lead time for third and fourth quarters is 6.52 days and the standard deviation is

1.35 days. Both the average production lead time and standard deviation are about 15 % improvement. Concerning the percent of order delay before July average is 34.7 % and after July is 9.3 %, 25.4 % improvement.

4 Conclusion

In this study, a simulation game and an enhancement of SDBR were developed to overcome two obstacles that block the introduction of SDBR to production managers. The first results support the notion that in most cases, variability is not the root cause of poor DDP and long PLT. Both were caused by erroneous production paradigms. The second results demonstrated by an IC assembly and test plant case study that applying CCPM buffer management method to enhance SDBR can significantly improve the due date performance as well as the production lead time for a high touch time production environment.

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Applying NGBM to Avoid Erroneous Grey Prediction

Chun-I Chen and Shou-Jen Huang

Abstract Grey theory is popular for many years. GM(1,1) is the most used model in grey theory. In the model, there are two coefficients *a* and *b* which are determined by lease square method. Base on our research result, the grey development coefficient *a* should not be zero. If it is, the prediction result is totally erroneous. The correct way to solve this problem is to adopt L'Hôpital Rule. In this paper, we also demonstrate how nonlinear grey Bernoulli model could avoid the appearance the singular situation and increase the prediction precision.

Keywords L'Hôpital Rule • NGBM • The grey development coefficient

1 Introduction

Grey model (GM) theory was proposed by Professor Deng in early 1982 [1]. Subsequently, it has developed rapidly and is applied extensively in the field of forecasting science for various areas, such as industry, economy, natural phenomenon, etc., during the last four decades [2–4].

We could find more and more scholars who apply GM (1, 1) to many applications, including social science, financial market and engineering so on [5–9]. Unfortunately, none of papers indicates that there is limitation to the grey development *a*. The grey development coefficient *a* should not equal to zero until we proposed it [10]. In this paper, we will demonstrate how this problem is solved by nonlinear grey Bernoulli model (NGBM) apart from our proposed L'Hôpital Rule [11].

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2 Methodologies

The solution to singular problem of GM (1, 1) by L'Hôpital Rule and NGBM are briefly described below:

2.1 Solving Singular Problem by L'Hôpital's Rule

The GM (1, 1) forecast equation, $\widehat{X}^{(0)}(k+1) = (1-e^{a})\left[x^{(0)}(1)-\frac{b}{a}\right]e^{-ak}$ or $\widehat{X}^{(1)}(k+1) = \left[x^{(0)}(1)-\frac{b}{a}\right]e^{-ak}+\frac{b}{a}$, will get an incorrect calculation when the developing coefficient a approaches or equal to 0.

Evaluate

$$\begin{aligned}&\lim_{a\to 0}\widehat{X}^{(0)}(k+1)\\ =&\lim_{a\to 0}\widehat{X}^{(0)}(1-e^{a})\ \left[x^{(0)}(1)-\frac{b}{a}\right)e^{-ak}.\end{aligned} \tag{1}$$

Solving Eq. (1) by differentiating both numerator and denominator as follow:

$$\lim_{a\to o}\frac{1-\mathrm{e}^{a}}{\mathrm{e}^{ak}/\mathrm{x}^{(0)}-\frac{b}{a}} = \frac{-1}{\left(\frac{-b}{b^2}\right)} = b$$

The above result shows that

$$\lim_{a\to 0}\widehat{X}^{(0)}(k+1) = b. \tag{2}$$

This is a very important result to researches who adopt grey theory as prediction tools.

Meanwhile, we can also use L'Hôpital's Rule to evaluate

$$\begin{aligned}&\lim_{a\to 0}\widehat{X}^{(1)}(k+1)\\ &=\lim_{a\to 0}\left\{\left[x^{(0)}(1)-\tfrac{b}{a}\right]e^{-ak}+\tfrac{b}{a}\right\}\\ &=\lim_{a\to 0}x^{(0)}(1)\mathrm{e}^{-ak}+\lim_{a\to 0}\frac{\mathrm{b}\left(1-e^{-ak}\right)}{a}\\ &=x^{(0)}(1)+k.\end{aligned} \tag{3}$$

The result is the same when solve the original grey differential equation by setting $a=0$. Then, we get

$$\begin{aligned}&\widehat{X}^{(1)}(t+1) = x^{(0)}(1)+bt.\\ &\text{and}\quad x^{(0)}(1) = x^{(1)}(1).\end{aligned} \tag{4}$$

From the calculation by L'Hôpital Rule, Eq. (3), or solution directly from differential equation, Eq. (4), we know the truth that both results are the same when a approaches 0.

This confirms that a cannot be substituted directly into the prediction equation of the GM (1, 1) model when the grey development coefficient a approaches or is equal to zero; instead, L'Hôpital Rule must be used to calculate the next predictive value, which is the b value.

$$\begin{aligned} \widehat{\mathrm{X}}^{(0)}(k+1) &= (1-\mathrm{e}^{a})\ \left[\mathrm{x}^{(0)}(1)-\tfrac{b}{a}\right]\mathrm{e}^{-ak} \\ &= b \\ \text{where}\ \ a &= 0 \end{aligned} \tag{5}$$

2.2 Solving Singular Problem by Nonlinear Grey Bernoulli Model

The nonlinear grey Bernoulli model (NGBM) is a forecast model, which features the simple inference process of the GM (1, 1) model, and promoting the forecast accuracy for nonlinear data. The inference process of NGBM is explained as follows:

Step 1: Raw data sequences to construct the model are the same as GM (1, 1).
Step 2: The NGBM differential and difference equations are established using the Bernoulli equation

$$\frac{dX^{(1)}}{dt} + aX^{(1)} = b\left[X^{(1)}\right]^{N} \tag{6}$$

In the equation, a is the development coefficient, b is the grey input, and power N is a real number not equal to 1.

The grey difference equation can be inferred as follows:

$$X^{(0)}(k) + aZ^{(1)}(k) = b\left[Z^{(1)}(k)\right]^{N}, k = 2, 3, \ldots, n \tag{7}$$

where $Z^{(1)}(k) = \alpha X^{(1)}(k) + (1-\alpha)Z^{(1)}(k-1), k = 2, 3, \ldots, n$

Generally, α is 0.5.

Step 3: Parameters a and b are solved using the least square method:

Putting raw data in the difference equation:

$$\begin{aligned} &X^{(0)}(2) + aZ^{(1)}(2) = b\left[Z^{(1)}(2)\right]^{N} \\ &X^{(0)}(3) + aZ^{(1)}(3) = b\left[Z^{(1)}(3)\right]^{N} \\ &\vdots \\ &X^{(0)}(n) + aZ^{(1)}(n) = b\left[Z^{(1)}(n)\right]^{N} \end{aligned} \tag{8}$$

Using the matrix method, $Y = B\theta$ of which, $Y = [X^{(0)}(2)X^{(0)}(3)\ \ldots\ X^{(0)}(n)]^T$

$$B = \begin{bmatrix} -\frac{1}{2}\left[X^{(1)}(1) + X^{(1)}(2)\right] & \left[-\frac{1}{2}\left[X^{(1)}(1) + X^{(1)}(2)\right]\right]^N \\ -\frac{1}{2}\left[X^{(1)}(2) + X^{(1)}(3)\right] & \left[-\frac{1}{2}\left[X^{(1)}(2) + X^{(1)}(3)\right]\right]^N \\ \vdots & \vdots \\ -\frac{1}{2}\left[X^{(1)}(n-1) + X^{(1)}(n)\right] & \left[-\frac{1}{2}\left[X^{(1)}(n-1) + X^{(1)}(n)\right]\right]^N \end{bmatrix} \tag{9}$$

Y is the raw data sequence, B is the data matrix, and $\theta = \begin{bmatrix} a \\ b \end{bmatrix}$ is the parameter list. Using the least squares method:

$$\theta = \left(B^T B\right)^{-1} B^T Y \tag{10}$$

Step 4: The accumulated forecast equation using the grey differential equation can be expressed as follows:

$$\widehat{X}^{(1)}(k+1) = \left[\left(X^{(0)}(1)^{(1-N)} - \frac{b}{a}\right)e^{-a(1-N)k} + \frac{b}{a}\right]^{\left(\frac{1}{1-N}\right)}, N \neq 1, k = 1 \sim \text{n} \tag{11}$$

In the equation, when $N = 0$, it is equivalent to the GM(1,1). When $N = 1$, the equation cannot be solved; therefore, (1/1 − N) is close to infinity.

Step 5: As in the GM(1,1) model, inverse accumulated generating operation (IAGO) is conducted on the forecast value obtained by the previous equation to calculate the actual forecast value:

$$\widehat{X}^{(0)}(K) = \widehat{X}^{(1)}(k) - \widehat{X}^{(1)}(k-1) \tag{12}$$

To examine the precision of the model proposed in this study, we adopted three statistical measures, namely relative percentage error (*RPE*) analysis, average relative percentage error (*ARPE*), and the rolling grey model (*RGM*) error analysis, to assess the model's precision, in which *ARPE* less than 10 % will be qualified excellent [12].

The three measures are defined as follows:

$$RPE = \varepsilon(k) = \frac{x^{(0)}(k) - \widehat{x}^{(0)}(k)}{x^{(0)}(k)} \times 100\ \%, \quad k = 2, 3, 4, \ldots, m \tag{13}$$

$$ARPE = \varepsilon(avg) = \frac{1}{m}\sum_{k=2}^{m} |\varepsilon(k)| \times 100\ \%, \quad k = 2, 3, 4, \ldots, m \tag{14}$$

$$\varepsilon\left(RGM, k+1\right) = \frac{x^{(0)}\left(k+1\right) - \widehat{x}^{(0)}\left(k+1\right)}{x^{(0)}\left(k+1\right)} \times 100\ \%, \quad k+1 \leqq m \tag{15}$$

where $x^{(0)}(k)$ is the actual value and $\widehat{x}^{(0)}(k)$ is the predicted value.

The *RPE* is a point percentage error analysis between actual and predicted value. The *ARPE* is an overall error analysis of whole predicted results. The *RGM* is the method of error analysis which takes the newest information into consideration and eliminates the oldest one.

3 Numerical Illustration

In this section, we use actual data from economic activities to verify the discussions where the second point value of the four original observation points sampled is identical to the fourth point value, singular phenomena, where the grey development coefficient $a = 0$, occur in the GM(1,1) four-point rolling prediction, causing prediction errors and meaningless results. In these cases, all of the methodologies in Sect. 2 should be adopted as the optimal and most reasonable solution.

Case: Nuclear Share of Total Electricity Net Generation from 2007 to 2011

Selected nuclear share of total electricity net generation between 2006 and 2011, with data (19.4, 19.6, 20.2, 19.6, 19.2[p]) ([p]as preliminary) be analyzed as practical examples. (Source: http://www.eia.gov/totalenergy/data/monthly/#nuclear for updated monthly). The prediction precision of the proposed method was examined using 4-points *RGM* error analysis based on the GM(1,1) model. The results verify that the disadvantages significantly influence the prediction accuracy of the GM (1, 1) model when the singular phenomena occurred.

From Table 1, however, when we sampled the share rates from 2007 to 2011 for prediction, the raw entries occurred, that is, the second (year of 2008) and fourth (year of 2010) values were identical with 19.6 %. After computerized calculation, the grey development coefficient a obtained by the Excel calculation was -2.7756×10^{-16}, and that from the Matlab calculation was 4.4409×10^{-16}. After integrating a into the prediction equation, we obtained extremely significant *RPE* ($\varepsilon(k)\%$), *ARPE* ($\varepsilon(avg)\%$), and *RGM* ($\varepsilon(RGM, k+1)\%$) errors.

Solution 1: By the L'Hôpital Rule

If singular phenomenon occurs when conducting GM (1, 1) rolling grey prediction, the L'Hôpital Rule should be adopted to obtain a correct prediction. Then the next predictive value should place the b (= 19.8 %) as the proper data. The results showed in Table 1 that the maximal *RPE* was reduced to 1.98 % ($\varepsilon(k = 2009)\,\%$), the $\varepsilon(avg)\%$ reduced to 1.34 %, and the error $\varepsilon(RGM, k+1)\%$ of 2011 was 3.13 %, indicating an improvement in minimizing prediction errors.

Table 1 The result of share rate of total electricity net generation

k	1	2	3	4	5		
	2007	2008	2009	2010	2011	a	
Actual value	19.4	19.6	20.2	19.6	19.2[p]	b	ε(avg) %
$\hat{x}^{(0)}$ (1 : 4) by Excel	19.4	15.84	15.84	15.84	15.84	-2.7756×10^{-16}	19.4
$\varepsilon(k)$ %		19.18	21.58	19.18		19.8	
			$\varepsilon(RGM, k+1)$ %		17.50		
$\hat{x}^{(0)}$ (1 : 4) by Matlab	19.4	19.80	19.80	19.80	19.80	4.4409×10^{-16}	1.34
$\varepsilon(k)$ %		1.02	1.98	1.02		19.8	
			$\varepsilon(RGM, k+1)$ %		3.13		
$\hat{x}^{(0)}$ (1 : 4) by L'Hôpital's Rules	19.4	19.80	19.80	19.80	19.80		1.34
$\varepsilon(k)$ %		1.02	1.98	1.02		19.8	
			$\varepsilon(RGM, k+1)$ %		3.13		
$\hat{x}^{(0)}$ (1 : 4) (NGBM, $N = 0.1$)	19.4	19.71	19.91	19.73	19.38	0.0479	0.89
$\varepsilon(k)$ %		0.89	0.55	1.45		15.0871	
			$\varepsilon(RGM, k+1)$ %		0.95		

Source: http://www.eia.gov/
[p]as preliminary, The version of Matlab 7.10.0 (2010a) is used

Solution 2: By the Nonlinear Grey Bernoulli Model(NGBM)

Nonlinear Grey Bernoulli Model (NGBM) is a nonlinear grey predicted model with an adjustable power N to tune the predicted value to fit the actual data. In this research, the power N is determined using a simple computer program, which calculates the minimum average relative percentage error (*ARPE*) of the forecast model.

We could make good use of the nonlinear characteristics of NGBM to avoid the singular phenomena successfully. Moreover, the prediction precision is better than others when the power n is 0.1, that is, $\varepsilon(avg)\%$, 0.89 %, and $\varepsilon(RGM, k+1)\%$, 0.95 %.

4 Conclusion

In this paper, we stress again the appearance of singular problem of GM(1,1). The correct handling procedure is by L'Hôpital Rule. We also suggest NGBM is more sufficient to deal with the singular problem. In this research, a practical case is adopted to show the effectiveness of NGBM.

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A Centroid Based Fuzzy Weighted Average for Ranking Alternatives

Ta-Chung Chu and P.A.H. Nguyen

Abstract This paper suggests ranking alternatives through a centroid based fuzzy weighted average (FWA) approach, where ratings of alternatives versus subjective criteria and the importance weights of all criteria are assessed in linguistic values represented by fuzzy numbers. Membership functions of the final fuzzy evaluation values of alternatives can be developed and the centroid ranking method is applied to defuzzify all the final fuzzy evaluation values to complete the model. Formulae of ranking procedure can be clearly developed to make execution of the proposed method more efficient. An example demonstrates feasibility of the proposed method.

Keywords Centroid • Fuzzy weighted average • Membership function • Ranking

1 Introduction

Fuzzy weighted average (FWA) is one of the most effective techniques in fuzzy multiple criteria decision making (MCDM) [1–3] and has been applied to resolve problems under uncertain environments.

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Many works have been studied in FWA. In 1987, Dong and Wang [4] considered computational aspect of sup-min convolution when applied to weighted average operations. They used a computational algorithm based on α-cut representation of fuzzy set, a nonlinear programming implementation of the extension principle and interval analysis. Their method provides a precise but distinct solution to FWA. Their method was further improved by subsequent works in [5–8].

Despite the merits, the above FWA methods cannot rank similar fuzzy numbers efficiently due to what they produced are approximate membership functions. Their calculations will be too tedious if many qualitative and quantitative criteria must be considered. These limitations certainly hinder their applicability to real world problems. The degree of accuracy in approximation depends on discretization refinement of the α-cut of fuzzy numbers [9]. To resolve the above problems, this work suggests a centroid based FWA method for ranking alternatives, in which membership functions of the final fuzzy evaluation values of alternatives can be developed. Membership functions of the final fuzzy evaluation values can be developed via interval arithmetic of fuzzy numbers. These fuzzy evaluation values must be defuzzified for decision making. Thus a ranking method is needed.

A comparison of ranking methods can be seen in [10–12]. Herein the centroid method [13] is applied to defuzzify all the final fuzzy evaluation values because it is one of the most commonly used ranking methods. Ranking formulas can be clearly developed to make execution of the proposed method more efficient. Finally a numerical example demonstrates feasibility of the proposed method.

2 Fuzzy Set

Fuzzy set theory was introduced by Zadeh (1965) [14, 15] and definition of fuzzy number can be seen in Dubois and Prade (1978) [16]. Suppose A^{α} is denoted by $A^{\alpha} = [A_l^{\alpha}, A_u^{\alpha}]$. Given fuzzy numbers A and $B \in R^{+}$, some main operations can be expressed as follows [17]:

$$(A \oplus B)^{\alpha} = \left[A_l^{\alpha} + B_l^{\alpha}, A_u^{\alpha} + B_u^{\alpha}\right] \tag{1}$$

$$(A \ominus B) = \left[A_l^{\alpha} - B_u^{\alpha}, A_u^{\alpha} - B_l^{\alpha}\right] \tag{2}$$

$$(A \otimes B)^{\alpha} = \left[A_l^{\alpha} \,.\, B_l^{\alpha}, A_u^{\alpha} \,.\, B_u^{\alpha}\right] \tag{3}$$

$$(A \oslash B)^{\alpha} = \left[\frac{A_l^{\alpha}}{B_u^{\alpha}}, \frac{A_u^{\alpha}}{B_l^{\alpha}}\right] \tag{4}$$

Herein the centroid [14] method is applied to defuzzify fuzzy values. Larger $x(A)$ leads to larger A.

$$x(A) = \frac{\int_{-\infty}^{+\infty} x f_A(x) dx}{\int_{-\infty}^{+\infty} f_A(x) dx} \tag{5}$$

3 Model Development

3.1 Determine Alternatives and Criteria

Assume that a committee of k decision makers (*i.e.* D_t, $t = 1 \sim k$) is formed to select m alternatives (*i.e.* A_i, $i = 1 \sim m$) and determine n selection criteria (*i.e.* C_j, $j = 1 \sim n$). Moreover, assume that the importance weights of the criteria and the performance ratings under each qualitative criterion are assessed in linguistic values represented by positive trapezoidal fuzzy numbers.

3.2 Aggregate Importance Weights

The importance weight assigned by each decision maker to each criterion can be assessed in a linguistic value represented by a positive trapezoidal fuzzy number. The weighting set can be {SI, FI, I, VI, EI}, where SI = Slightly Important, FI = Fairly Important, I = Important, VI = Very Important, EI = Extremely Important and SI = (0,0,0.1,0.3), FI = (0,0.2,0.3,0.5), I = (0.3,0.45,0.55,0.7), VI = (0.5,0.7,0.8,1), EI = (0.7,0.9,1,1). Let $w_{jt} = (o_{jt},\ p_{jt},\ q_{jt},\ r_{jt})$, $w_{jt} \in R^+$, $j = 1, 2, \ldots, n$, $t = 1, 2, \ldots, k$, be the importance weight given by decision-maker D_t to criterion C_j. The aggregated importance weight, w_j of criterion C_j assessed by the committee of k decision-makers can be evaluated as:

$$w_j = \left(\frac{1}{k}\right) \otimes \left(w_{j1} \oplus w_{j2} \oplus \cdots \oplus w_{jk}\right),$$

$$o_j = \sum_{t=1}^{k} \frac{o_{jt}}{k}, b_j = \sum_{t=1}^{k} \frac{p_{jt}}{k}, c_j = \sum_{t=1}^{k} \frac{q_{jt}}{k}, d_j = \sum_{t=1}^{k} \frac{r_{jt}}{k}. \tag{6}$$

3.3 Aggregate Ratings of Alternatives Versus Qualitative Criteria

Let $x_{ijt} = (a_{ijt}, b_{ijt}, c_{ijt}, d_{ijt})$, $x_{ijt} \in R^+$, $i = 1, 2, \ldots, m$, $j = 1, 2, \ldots, e$, $t = 1, 2, \ldots, k$, be the linguistic rating assigned to A_i by D_t under C_j. The aggregated ratings, x_{ij} of A_i under C_j assessed by k decision-makers can be evaluated as:

$$x_{ij} = \left(\frac{1}{k}\right) \otimes \left(x_{ij1} \oplus \; x_{ij2} \; \oplus \cdots \oplus x_{ijk}\right),$$

$$a_{ij} = \sum_{t=1}^{k} \frac{a_{ijt}}{k}, b_{ij} = \sum_{t=1}^{k} \frac{b_{ijt}}{k}, c_{ij} = \sum_{t=1}^{k} \frac{c_{ijt}}{k}, d_{ij} = \sum_{t=1}^{k} \frac{d_{ijt}}{k}. \tag{7}$$

3.4 Normalize Ratings of Alternatives Versus Quantitative Criteria

Quantitative criteria values x_{ij} may have different units. Thus all ratings of alternatives versus quantitative criteria must be normalized into a comparable scale for calculation rationale. Herein "normal distribution" concept is applied to normalize quantitative data [9].

Benefit criteria: $C_j, j = (e+1) \sim f$ The larger the better

$$\text{Normalization equations:} \; x_{ij} = 1 - P\left(h_{ij}\right) \tag{8}$$

Cost criteria: $C_j, j = (f+1) \sim n$ The smaller the better

$$\text{Normalization equations:} \; x_{ij} = P\left(h_{ij}\right) \tag{9}$$

where $h_{ij} = \frac{g_{ij} - \overline{g}_j}{s_j}$, h_{ij} = Student's t-score for alternative A_i versus criterion C_j, g_{ij} = Non-normalized quantitative data of alternative A_i versus criterion C_j; $s_j = \sqrt{\frac{\sum_{i=1}^{m}\left(g_{ij} - \overline{g}_j\right)}{m-1}}$, s_j = Standard deviation of criterion C_j from alternatives $A_i, i = 1 \sim m$. $\overline{g}_j = \frac{1}{m}\sum_{i=1}^{m} g_{ij}$, $\overline{g}_j$ = The mean of non-normalized quantitative data from alternative $A_i, i = 1 \sim m$.

3.5 Develop Membership Function for FWA

A fuzzy weighted average (FWA) is shown as follows:

$$T_i = \frac{(w_1 \otimes x_{i1}) \oplus \ldots \oplus \left(w_j \otimes x_{ij}\right) \oplus \ldots \oplus (w_n \otimes x_{in})}{w_1 \oplus \ldots \oplus w_j \oplus \ldots \oplus w_n} \tag{10}$$

Via Eqs. (1), (2), (3), and (4), the membership functions for FWA (*i.e.* T_i in (10)) can be developed. Firstly, $T_i^{\alpha} = [T_{il}^{\alpha},\ T_{iu}^{\alpha}]$

$$T_{il}^{\alpha} = \frac{\left(\sum_{j=1}^{n} (p_j - o_j)(b_{ij} - a_{ij})\right)\alpha^2 + \left(\sum_{j=1}^{n} \left[o_j (b_{ij} - a_{ij}) + a_{ij} (p_j - o_j)\right]\right)\alpha + \sum_{j=1}^{n} o_j a_{ij}}{\sum_{j=1}^{n} (q_j - r_j)\alpha + \sum_{j=1}^{n} r_j} \tag{11}$$

$$T_{iu}^{\alpha} = \frac{\left(\sum_{j=1}^{n} (q_j - r_j)(c_{ij} - d_{ij})\right)\alpha^2 + \left(\sum_{j=1}^{n} \left[r_j (c_{ij} - d_{ij}) + d_{ij} (q_j - r_j)\right]\right)\alpha + \sum_{j=1}^{n} r_j d_{ij}}{\sum_{j=1}^{n} (p_j - o_j)\alpha + \sum_{j=1}^{n} o_j} \tag{12}$$

$$\text{Let } \sum_{j=1}^{n} o_j a_{ij} = U_i, \quad \sum_{j=1}^{n} p_j b_{ij} = V_i, \quad \sum_{j=1}^{n} q_j c_{ij} = Y_i, \quad \sum_{j=1}^{n} r_j d_{ij} = Z_i$$

$$\sum_{j=1}^{n} o_j = H_1, \quad \sum_{j=1}^{n} p_j = H_2, \quad \sum_{j=1}^{n} q_j = H_3, \quad \sum_{j=1}^{n} r_j = H_4,$$

$$\sum_{j=1}^{n} (p_j - o_j) = G_1, \quad \sum_{j=1}^{n} (q_j - r_j) = G_2$$

$$\sum_{j=1}^{n} (p_j - o_j)(b_{ij} - a_{ij}) = E_{i1}, \quad \sum_{j=1}^{n} \left[o_j (b_{ij} - a_{ij}) + a_{ij} (p_j - o_j)\right] = F_{i1}$$

$$\sum_{j=1}^{n} (q_j - r_j)(c_{ij} - d_{ij}) = E_{i2}, \quad \sum_{j=1}^{n} \left[r_j (c_{ij} - d_{ij}) + d_{ij} (q_j - r_j)\right] = F_{i2}$$

Equations (11) and (12) lead to two equations to solve:

$$E_{i1}\alpha^2 + (F_{i1} - G_2 x)\,\alpha + U_i - H_4 x = 0 \tag{13}$$

$$E_{i2}\alpha^2 + (F_{i2} - G_1 x)\,\alpha + Z_i - H_1 x = 0 \tag{14}$$

The left and right membership functions, *i.e.* $f^L_{\overline{y}_i}(x)$ and $f^R_{\overline{y}_i}(x)$, of $\overline{y}_i$ can be derived as:

$$\begin{array}{ll} f^L_{T_i}(x) = \frac{G_2 x - F_{i1} + \left[G_2^2 x^2 + I_{i1} x + J_{i1}\right]^{1/2}}{2E_{i1}}, & U_i/H_4 \le x \le V_i/H_3, \\ 1, & V_i/H_3 \le x \le Y_i/H_2, \\ f^R_{T_i}(x) = \frac{G_1 x - F_{i2} - \left[G_1^2 x^2 + I_{i2} x + J_{i2}\right]^{1/2}}{2E_{i2}}, & Y_i/H_2 \le x \le Z_i/H_1. \end{array} \tag{15}$$

where $I_{i1} = 4E_{i1}H_4 - 2F_{i1}G_2$, $J_{i1} = F_{i1}^2 - 4E_{i1}U_i$, $I_{i2} = 4E_{i2}H_1 - 2F_{i2}G_1$, $J_{i2} = F_{i2}^2 - 4E_{i2}Z_i$, $E_{i1} \neq 0$ and $E_{i2} \neq 0$.

For convenience, T_i can be expressed as:

$$T_i = \left(\frac{U_i}{H_4}, \frac{V_i}{H_3}, \frac{Y_i}{H_2}, \frac{Z_i}{H_1}; \quad E_{i1}, F_{i1}, G_2, I_{i1}, J_{i1}; \quad E_{i2}, F_{i2}, G_1, I_{i2}, J_{i2}\right), \quad i = 1, 2, \ldots, m. \tag{16}$$

3.6 Obtain Ranking Values

By Eq. (5) to obtain centroid value of T_i on x-axis as:

$$x(T_i) = \frac{\int x f_{T_i}(x)dx}{\int f_{T_i}(x)dx} = \frac{\int x f^L_{T_i}(x)dx + \int x dx + \int x f^R_{T_i}(x)dx}{\int f^L_{T_i}(x)dx + \int dx + \int f^R_{T_i}(x)dx} \tag{17}$$

New ranking formulas for Eq. (17) can be developed as Eqs. (18), (19), (20), (21), (22), and (23) as follows:

$$\int xf_{T_i}^{L}(x)dx = \int_{U_{i/H_4}}^{V_{i/H_3}} x\frac{G_2x - F_{i1} - \left[G_2^2x^2 + I_{i1}x + J_{i1}\right]^{1/2}}{2E_{i1}}dx$$
$$= \frac{1}{2E_{i1}}\int_{U_i/H_4}^{V_i/H_3} G_2x^2 - \frac{1}{2E_{i1}}\int_{U_i/H_4}^{V_i/H_3} F_{i1}x\,dx - \frac{1}{2E_{i1}}\int_{U_i/H_4}^{V_i/H_3} x\left[G_2^2x^2 + I_{i1}x + J_{i1}\right]^{1/2}dx$$
$$= \frac{G_2}{6E_{i1}}\left(\left(\frac{V_i}{H_3}\right)^3 - \left(\frac{U_i}{H_4}\right)^3\right) - \frac{F_{i1}}{4E_{i1}}\left(\left(\frac{V_i}{H_3}\right)^2 - \left(\frac{U_i}{H_4}\right)^2\right)$$
$$+ \frac{1}{2E_{i1}}\left[\frac{1}{48G_2^{5/2}}\left(2G_2\left(G_2^2\left(\left(\frac{V_i}{H_3}\right)^2 - \left(\frac{U_i}{H_4}\right)^2\right) + I_{i1}\left(\frac{V_i}{H_3} - \frac{U_i}{H_4}\right) + J_{i1}\right)^{\frac{1}{2}}\right.\right.$$
$$- \left(3{I_{i1}}^2 + 2G_2^2I_{i1}\left(\frac{V_i}{H_3} - \frac{U_i}{H_4}\right) + 8G_2^2\left(J_{i1} + G_2^2\left(\left(\frac{V_i}{H_3}\right)^2 - \left(\frac{U_i}{H_4}\right)^2\right)\right)\right)$$
$$+ 3\left({I_{i1}}^3 - 4G_2^2I_{i1}J_{i1}\right)\ln\left|I_{i1} + 2G_2^2\left(\frac{V_i}{H_3} - \frac{U_i}{H_4}\right)\right.$$
$$+ 2G_2\left(G_2^2\left(\left(\frac{V_i}{H_3}\right)^2 - \left(\frac{U_i}{H_4}\right)^2\right)\right.$$
$$\left.\left.\left. + I_{i1}\left(\frac{V_i}{H_3} - \frac{U_i}{H_4}\right) + \left(\frac{V_i}{H_3} - \frac{U_i}{H_4}\right)\right)^{\frac{1}{2}}\right)\right] \tag{18}$$

$$\int_{V_i/H_3}^{Y_i/H_2} x\,dx = \frac{1}{2}\left[\left(\frac{Y_i}{H_2}\right)^2 - \left(\frac{V_i}{H_3}\right)^2\right] \tag{19}$$

$$\int xf_{T_i}^{R}(x)dx = \int_{Z_{i/H_1}}^{Y_{i/H_2}} x\frac{G_1x - F_{i2} - \left[G_1^2x^2 + I_{i2}x + J_{i2}\right]^{1/2}}{2E_{i2}}dx$$
$$= \frac{G_1}{6E_{i2}}\left(\left(\frac{U_i}{H_4}\right)^3 - \left(\frac{V_i}{H_3}\right)^3\right) + \frac{F_{i2}}{4E_{i2}}\left(\left(\frac{U_i}{H_4}\right)^2 - \left(\frac{V_i}{H_3}\right)^2\right)$$
$$+ \frac{1}{2E_{i2}}\left[\frac{1}{48G_1^5}\left(2G_1\left(G_1^2\left(\left(\frac{V_i}{H_3}\right)^2 - \left(\frac{U_i}{H_4}\right)^2\right) + I_{i2}\left(\frac{V_i}{H_3} - \frac{U_i}{H_4}\right) + J_{i2}\right)^{\frac{1}{2}}\right.\right.$$
$$- \left(3{I_{i2}}^2 + 2G_1^2I_{i2}\left(\frac{V_i}{H_3} - \frac{U_i}{H_4}\right) + 8G_1^2\left(J_{i2} + G_1^2\left(\left(\frac{V_i}{H_3}\right)^2 - \left(\frac{U_i}{H_4}\right)^2\right)\right)\right)$$
$$+ 3\left({I_{i2}}^3 - 4G_1^2I_{i2}J_{i2}\right)\ln\left|I_{i2} + 2G_1^2\left(\frac{V_i}{H_3} - \frac{U_i}{H_4}\right)\right.$$
$$\left.\left.\left. + 2G_1\left(G_1^2\left(\left(\frac{V_i}{H_3}\right)^2 - \left(\frac{U_i}{H_4}\right)^2\right) + I_{i2}\left(\frac{V_i}{H_3} - \frac{U_i}{H_4}\right) + \left(\frac{V_i}{H_3} - \frac{U_i}{H_4}\right)\right)^{\frac{1}{2}}\right)\right] \tag{20}$$

$$\int f_{T_i}^L(x)dx = \int_{U_i/H_4}^{V_i/H_3} \frac{G_2 x - F_{i1} - \left[G_2^2 x^2 + I_{i1}x + J_{i1}\right]^{1/2}}{2E_{i1}} dx$$
$$= \frac{G_2}{4E_{i1}}\left(\left(\frac{V_i}{H_3}\right)^2 - \left(\frac{U_i}{H_4}\right)^2\right) - \frac{F_{i1}}{2E_{i1}}\left(\left(\frac{V_i}{H_3}\right)^2 - \left(\frac{U_i}{H_4}\right)^2\right)$$
$$-\frac{1}{2E_{i1}}\left[\frac{I_{i1}+2G_2^2\left(\frac{V_i}{H_3}-\frac{U_i}{H_4}\right)}{4G_2^2}\left[G_2^2\left[\left(\frac{V_i}{H_3}\right)^2-\left(\frac{U_i}{H_4}\right)^2\right]+I_{i1}\left(\frac{V_i}{H_3}-\frac{U_i}{H_4}\right)+J_{i1}\right]^{\frac{1}{2}}\right.$$
$$+\frac{4G_2^2 J_{i1} - {I_{i1}}^2}{8\left(G_2^2\right)\frac{3}{2}} \ln\left|2G_2^2\left(\frac{V_i}{H_3} - \frac{U_i}{H_4}\right) + I_{i1}\right.$$
$$\left.+2\left[G_2^2\left(G_2^2\left[\left(\frac{V_i}{H_3}\right)^2 - \left(\frac{U_i}{H_4}\right)^2\right] + I_{i1}\left(\frac{V_i}{H_3} - \frac{U_i}{H_4}\right) + J_{i1}\right)\right]^{\frac{1}{2}}\right] \tag{21}$$

$$\int dx = \left[\left(\frac{Y_i}{H_2}\right) - \left(\frac{V_i}{H_3}\right)\right] \tag{22}$$

$$\int f_{T_i}^R(x)dx = \int_{Z_i/H_1}^{Y_i/H_2} \frac{G_1 x - F_{i2} - \left[G_1^2 x^2 + I_{i2}x + J_{i2}\right]^{1/2}}{2E_{i2}} dx$$
$$= \frac{G_1}{4E_{i2}}\left(\left(\frac{V_i}{H_3}\right)^2 - \left(\frac{U_i}{H_4}\right)^2\right) - \frac{F_{i2}}{2E_{i2}}\left(\left(\frac{V_i}{H_3}\right)^2 - \left(\frac{U_i}{H_4}\right)^2\right)$$
$$-\frac{1}{2E_{i2}}\left[\frac{I_{i2}+2G_1^2\left(\frac{V_i}{H_3}-\frac{U_i}{H_4}\right)}{4G_1^2}\left[G_1^2\left[\left(\frac{V_i}{H_3}\right)^2-\left(\frac{U_i}{H_4}\right)^2\right]+I_{i2}\left(\frac{V_i}{H_3}-\frac{U_i}{H_4}\right)+J_{i2}\right]^{\frac{1}{2}}\right.$$
$$+\frac{4G_1^2 J_{i2} - {I_{i2}}^2}{8\left(G_1^2\right)\frac{3}{2}} \ln\left|2G_1^2\left(\frac{V_i}{H_3} - \frac{U_i}{H_4}\right) + I_{i2}\right.$$
$$\left.+2\left[G_1^2\left(G_1^2\left[\left(\frac{V_i}{H_3}\right)^2 - \left(\frac{U_i}{H_4}\right)^2\right] + I_{i2}\left(\frac{V_i}{H_3} - \frac{U_i}{H_4}\right) + J_{i2}\right)\right]^{\frac{1}{2}}\right] \tag{23}$$

Applying Eqs. (18), (19), (20), (21), (22) and (23) to (17), the centroid value of each alternative (*i.e.* $C(T_i)$) can be obtained. Obviously, if $C(T_1) > C(T_2)$, then $T_1 > T_2$; if $C(T_1) = C(T_2)$, then $T_1 = T_2$; and if $C(T_1) < C(T_2)$, then $T_1 < T_2$.

4 Numerical Example

Assume that a committee of five decision makers, including General Manager (D_1), Financial Manager (D_2), Customer Service Manager (D_3) and R&D Manager (D_4) are responsible for evaluating a group of BI systems which are A_1, A_2, A_3, A_4 and A_5 under nine criteria (C_j, $j = 1,2,\ldots,9$). The nine criteria are classified to benefic qualitative, such as decision management ($C_{1)}$, intelligence text mining (C_2), risk management (C_3), flexibility (C_4), and ease of use (C_5), cost quantitative, such as, cost (C_6) and real timing (C_7), and benefit quantitative, such as time to market (C_8) and number of functionality (C_9).

Suppose the linguistic weighting values in Sect. 3.2 are used by decision makers to evaluate the importance weights of criteria as shown in Table 1. Through Eq. (6), the average weights of the criteria can be obtained as also shown in Table 1. Suppose linguistic values, such as Very Low (VL) = (0,0,0.1,0.3), Low (L) = (0,0.2,0.3,0.4), Medium (M) = (0.3,0.4,0.6,0.7), High (H) = (0.5,0.7,0.8,0.9), Very High (VH) = (0.8,0.9,1,1), are used to evaluate ratings of alternatives versus qualitative criteria as shown in Table 2. Via Eq. (7), the average ratings of alternatives can be obtained as also shown in Table 2. In addition, assume that values of the four quantitative criteria are listed in Table 3, and Eqs. (8) and (9) produce their normalized values as shown in Table 4.

By Eqs. (10), (11), (12), (13), (14), (15), and (16), T_i, $i = 1, \ldots, 5$, can be developed as:

$$
\begin{aligned}
T_1 = {} & (0.198, 0.4, 0.686, 1.27; 0.0963, 0.7834, 1.35, 4.479, .0963, 0.7834, 1.35, \\
& 4.479, 0.0984; 0.0613, 0.9748, -0.12, 3.4038, 0.0299) \\
T_2 = {} & (0.273, 0.553, 0.923, 1.702; 0.1125, 1.1111, 1.35, 5.7041, 0.4049; 0.0513, \\
& -1.2614, -1.2, 4.0514, 0.4918) \\
T_3 = {} & (0.188, 0.327, 0.648, 1.216; 0.0937, 0.7011, 1.35, 4.214, 0.0147; 0.0613, \\
& -0.9757, -1.2, 3.4061, 0.0133)
\end{aligned}
$$

Table 1 Importance weights of criteria and average weights

	Decision makers				
Criteria	D_1	D_2	D_3	D_4	Average weights
C_1	EI	VI	VI	EI	(0.650,0.800,0.900,1.000)
C_2	FI	I	VI	SI	(0.200,0.350,0.475,0.625)
C_3	EI	EI	VI	VI	(0.650,0.800,0.900,1.000)
C_4	SI	VI	I	FI	(0.200,0.350,0.475,0.625)
C_5	SI	FI	I	SI	(0.075,0.175,0.300,0.450)
C_6	FI	I	VI	SI	(0.200,0.350,0.475,0.625)
C_7	FI	EI	VI	FI	(0.325,0.500,0.650,0.750)
C_8	VI	VI	VI	EI	(0.575,0.750,0.850,1.000)
C_9	I	VI	I	SI	(0.275,0.425,0.525,0.675)

Table 2 Ratings of alternatives and average ratings

Alternatives / Criteria		Decision makers				Average ratings
		D_1	D_2	D_3	D_4	
A_1	C_1	VH	H	H	VI	(0.6000, 0.7250, 0.8500, 0.9000)
	C_2	L	M	H	VL	(0.5250, 0.6750, 0.8000, 0.8750)
	C_3	VH	VH	H	H	(0.5250, 0.6750, 0.8000, 0.8750)
	C_4	VL	H	M	L	(0.0000, 0.1000, 0.2000, 0.3500)
	C_5	VL	L	M	VL	(0.0750, 0.2500, 0.3750, 0.4750)
A_2	C_1	M	H	L	H	(0.3250, 0.5000, 0.6250, 0.7250)
	C_2	M	H	VH	H	(0.5250, 0.6750, 0.8000, 0.8750)
	C_3	H	H	VH	H	(0.5750, 0.7500, 0.8500, 0.9250)
	C_4	M	H	H	M	(0.4000, 0.5500, 0.7000, 0.8000)
	C_5	VH	H	VH	H	(0.6500, 0.8000, 0.9000, 0.9500)
A_3	C_1	VH	H	VH	VH	(0.7250, 0.8500, 0.9500, 0.9750)
	C_2	H	M	M	L	(0.2750, 0.4250, 0.5750, 0.6750)
	C_3	M	M	M	H	(0.3500, 0.4750, 0.6500, 0.7500)
	C_4	VL	M	L	L	(0.0750, 0.2000, 0.3250, 0.4500)
	C_5	H	H	M	M	(0.4000, 0.5500, 0.7000, 0.8000)
A_4	C_1	L	L	M	L	(0.0750, 0.2500, 0.3750, 0.4750)
	C_2	VH	M	H	L	(0.4000, 0.5500, 0.6750, 0.7500)
	C_3	VH	H	H	H	(0.5750, 0.7500, 0.8500, 0.9250)
	C_4	VH	H	M	H	(0.5250, 0.6750, 0.8000, 0.8750)
	C_5	H	M	M	H	(0.4000, 0.5500, 0.7000, 0.8000)
A_5	C_1	H	H	VH	H	(0.5750, 0.7500, 0.8500, 0.9250)
	C_2	H	M	VL	H	(0.3250, 0.4500, 0.5750, 0.7000)
	C_3	H	M	M	H	(0.4000, 0.5500, 0.7000, 0.8000)
	C_4	M	H	H	L	(0.3250, 0.5000, 0.6250, 0.7250)
	C_5	VL	H	M	L	(0.2000, 0.3250, 0.4500, 0.5750)

Table 3 Values of quantitative alternatives

	Alternatives				
Quantitative criteria	A_1	A_2	A_3	A_4	A_5
C_6	20	35	70	10	80
C_7	10	5	50	15	20
C_8	0.467	1.25	0.833	1.2	1.111
C_9	0.7	1	1	0.6	1

Table 4 Normalized values of quantitative alternatives

	Alternatives				
Quantitative criteria	A_1	A_2	A_3	A_4	A_5
C_6	0.752	0.596	0.215	0.828	0.148
C_7	0.699	0.778	0.083	0.604	0.500
C_8	0.098	0.780	0.345	0.739	0.654
C_9	0.229	0.744	0.744	0.127	0.744

$$T_4 = (0.216, 0.455, 0.776, 1.451; 0.1125, 0.9533, 1.35, 5.3254, 0.2521; 0.0550, -1.132, -1.2, 3.7498, 0.2758)$$

$$T_5 = (0.23, 0.457, 0.765, 1.428; 0.1063, 0.8801, 1.35, 4.9809, 0.1151; 0.07, -1.1262, -1.2, 3.9228, 0.009)$$

The centroid values of alternatives can be obtained through Eqs. (17), (18), (19), (20), (21), (22), and (23) as $C(T_1) = 266.925$, $C(T_2) = 1,358.609$, $C(T_3) = 223.132$, $C(T_4) = 402.491$ and $C(T_5) = 294.810$. The ranking order is $A_2 > A_4 > A_5 > A_1 > A_3$.

5 Conclusions

A centroid based FWA for ranking alternatives has been proposed, where formulae for the membership functions of the final fuzzy evaluation values from FWA can be derived. New formulas of ranking procedure have been developed to make proposed method more applicable. A numerical example has demonstrated feasibility of the proposed method. The proposed method can be applied to solve other fuzzy decision making problems under multiple criteria. However, the following issues are worth closer study: (1) a comparison of the proposed method to the other similar ones, such as that of [2] might be conducted to present difference; (2) the outcome could be different if normalization formulas, linguistic ratings and weightings, number of decision maker etc. are different; (3) number of criteria can be adjusted upon needed; (4) further research may try to justify the effectiveness of the proposed method in a case study.

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Forecasting the Output Values of Taiwan Bicycles and Spare Parts with Fourier Modified Grey Model

Lei-Chuan Lin, Shan-Yau Wu, and Ying-Fang Huang

Abstract In this study, the conventional Grey forecasting model GM(1,1) was investigated. And to enhance the accuracy of the forecasting model, the residuals were modified with Fourier series. The Fourier modified models called FGM(1,1) have very low values of mean absolute percentage error (MAPE) of 0.18 % and 2.63 %, respectively to the case of output values of bicycles and spare parts in Taiwan. These models were also tested for their forecasting ability in year 2011 that resulted in MAPE values of 8.45 % and 5.71 % respectively which make the models considered good to do the forecasting for the years 2012–2015.

Keywords Fourier residual modification • FGM (1, 1) • GM (1, 1)

1 Introduction

Global warming has been widely acknowledged as one of the most critical issue recently. As the world population grows fast and energy demand increases, the world is now facing with energy crisis, environment pollution. In the recent years, there has been a strong trend worldwide in using bicycles as a mean of transportation for travelling to and fro.

In bicycle industry, Taiwan is one of the top global manufacturers and suppliers of high and medium-end bicycles. There were too many orders for bicycles placed to Taiwan in early 1960s. Since 1967, Taiwan bicycle manufacturers have expanded internationally. The innovative new materials, functions and designs of Taiwan bicycles have gained acknowledgement from consumers worldwide. By establishing and promoting their own brands, Taiwan manufacturers have achieved the brand

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loyalty needed to compete with foreign brands. For years, Taiwan bicycle producers have been focusing on developing new materials and fabrication technologies. Instead of high-volume and low-cost products, Taiwan pursues high-tech and value-added products. Such high priced and high-end bicycles have increased profits despite the competitions from China.

There are many different factors that affect the output values of the industry, including manufacturing technology, consumption demand, advances in material sciences, etc., which are neither easily assessed nor fully collected. Therefore, it is therefore suggested to use Grey forecasting model GM(1,1) which is usually to deal with systems that are characterized by small sample data and/or for which information is lacking [1]. Liu [2] made a summary of the advances of Grey theory and its various applications. However, the conventional GM(1,1) model has low accuracy level. Thus, in order to enhance the forecasting power of GM(1,1), its residuals are proposed to be modified with Fourier series to create a new model named Fourier modified Grey forecasting model (FGM(1,1)). In the empirical study of bicycle and spare part industry in Taiwan, this modified model is then tested for its accuracy model before being used to forecast the output values of the industry from 2012 to 2015.

2 Methodology

Grey theory was originally proposed in 1982 to offer a new approach to deal mainly with the problems of uncertainty with few data points and/or poor information which is said to be "partial known, partial unknown" [1–3]. The core of grey theory is the grey dynamic model (GM). The Grey model is used to execute the short-term forecasting operation with no strict hypothesis for the distribution of the original data series [4–8].

The general GM model appears in the form of GM(d,v), where d is the rank of differential equation and v is the number of variables appeared in the equation. The fundamental model of Grey model is GM(1,1), called first-order differential model with one input variable.

The overall procedure to obtain GM(1,1) is as the following.

Step 1: Suppose an original series with n entries is $x^{(0)}$:

$$x^{(0)} = \left\{x^{(0)}(1), x^{(0)}(2), x^{(0)}(3), \ldots, x^{(0)}(k), \ldots x^{(0)}(n)\right\} \tag{1}$$

where $x^{(0)}(k)$ is the value at time k $\left(k = \overline{1, n}\right)$.

Step 2: From the original series $x^{(0)}$, a new series $x^{(1)}$ can be generated by one time accumulated generating operation (1-AGO), which is

$$x^{(1)} = \left\{x^{(1)}(1), x^{(1)}(2), x^{(1)}(3), \ldots, x^{(1)}(k), \ldots, x^{(1)}(n)\right\} \tag{2}$$

where $x^{(1)}(k) = \sum_{j=1}^{k} x^{(0)}(j)$

Step 3: A first-order differential equation with one variable is expressed as:

$$\frac{dx^{(1)}}{dt} + ax^{(1)} = b \tag{3}$$

where a is called a developing coefficient and b is called a grey input coefficient. These two coefficients can be determined by the least square method as the following:

$$[a, b]^T = \left(B^T B\right)^{-1} B^T Y \tag{4}$$

where

$$B = \begin{bmatrix} -\left(x^{(1)}(1) + x^{(1)}(2)\right)/2 & 1 \\ -\left(x^{(1)}(2) + x^{(1)}(3)\right)/2 & 1 \\ \cdots & \cdots \\ -\left(x^{(1)}(n-1) + x^{(1)}(n)\right)/2 & 1 \end{bmatrix}$$

$$Y = \left[x^{(0)}(2), x^{(0)}(3), \ldots, x^{(0)}(n)\right]^T$$

Therefore, the solution of Eq. (3) is expressed as:

$$x^{(1)}(t) = \left[x^{(1)}(1) - \frac{b}{a}\right] e^{-at} + \frac{b}{a} \tag{5}$$

Equation (5) is also known as time response function of the differential equation. From Eq. (5), the time response function of the GM(1,1) is given by:

$$\widehat{x}^{(1)}(k) = \left[x^{(0)}(1) - \frac{b}{a}\right] e^{-a(k-1)} + \frac{b}{a} \qquad \left(k = \overline{1, n}\right) \tag{6}$$

Based on the operation of one time inverse accumulated generating operation (1-IAGO), the predicted series $\widehat{x}^{(0)}$ can be obtained as the following:

$$\widehat{x}^{(0)} = \left\{x^{(0)}(1), \widehat{x}^{(0)}(2), x^{(0)}(3), \ldots, \widehat{x}^{(0)}(k), \ldots x^{(0)}(n)\right\} \tag{7}$$

where $\begin{cases} \widehat{x}^{(0)}(1) = x^{(0)}(1) \\ x^{(0)}(k) = x^{(1)}(k) - x^{(1)}(k-1) \end{cases} \quad \left(k = \overline{2, n}\right)$

In order to improve the accuracy of forecasting models, the Fourier series has been widely and successfully applied in modifying the residuals in Grey forecasting model GM(1,1) [1, 9, 10] which reduces the values of RMSE, MAE, MAPE, etc., And the overall procedure to obtain the modified model is as the followings. Let x is the original series of n entries and $\widehat{x}$ is the predicted series obtained from GM(1,1). Based on the predicted series $\widehat{x}$, a residual series named ε is defined as:

$$\varepsilon = \{\varepsilon(2), \varepsilon(3), \varepsilon(4), \ldots, \varepsilon(k), \ldots, \varepsilon(n)\} \tag{8}$$

where $\varepsilon(k) = x(k) - \widehat{x}(k) \qquad \left(k = \overline{2, n}\right)$

Expressed in Fourier series, $\varepsilon(k)$ is rewritten as:

$$\varepsilon(k) = \frac{1}{2}a_0 + \sum_{i=1}^{F} \left[a_i \cos\left(\frac{2\pi i}{n-1}k\right) + b_i \sin\left(\frac{2\pi i}{n-1}k\right) \right] \tag{9}$$

where $F = [(n-1)/2 - 1]$ called the minimum deployment frequency of Fourier series and only take integer number [1, 9, 11, 12].

Let P and C be defined as the following:

$$P = \begin{bmatrix} \frac{1}{2} & \cos\left(\frac{2\pi \times 1}{n-1} \times 2\right) & \sin\left(\frac{2\pi \times 1}{n-1} \times 2\right) & \cdots \cos\left(\frac{2\pi \times F}{n-1} \times 2\right) & \sin\left(\frac{2\pi \times F}{n-1} \times 2\right) \\ \frac{1}{2} & \cos\left(\frac{2\pi \times 1}{n-1} \times 3\right) & \sin\left(\frac{2\pi \times 1}{n-1} \times 3\right) & \cdots \cos\left(\frac{2\pi \times F}{n-1} \times 3\right) & \sin\left(\frac{2\pi \times F}{n-1} \times 3\right) \\ \cdots & \cdots & \cdots & \cdots \quad \cdots & \cdots \\ \frac{1}{2} & \cos\left(\frac{2\pi \times 1}{n-1} \times n\right) & \sin\left(\frac{2\pi \times 1}{n-1} \times n\right) & \cdots \cos\left(\frac{2\pi \times F}{n-1} \times n\right) & \sin\left(\frac{2\pi \times F}{n-1} \times n\right) \end{bmatrix}$$

$$C = [a_0, a_1, b_1, a_2, b_2, \ldots, a_F, b_F]^T$$

Then, the residual series is rewritten as:

$$\varepsilon = P.C \tag{10}$$

The parameters $a_0, a_1, b_1, a_2, b_2, \ldots, a_F, b_F$ are obtained by using the ordinary least squares method (OLS) which results in the equation of:

$$C = \left(P^T P\right)^{-1} P^T [\varepsilon]^T$$

Once the parameters are calculated, the modified residual series $\widehat{\varepsilon}$ is then achieved based on the following expression:

$$\widehat{\varepsilon}(k) = \frac{1}{2}a_0 + \sum_{i=1}^{F} \left[a_i \cos\left(\frac{2\pi i}{n-1}k\right) + b_i \sin\left(\frac{2\pi i}{n-1}k\right) \right] \tag{11}$$

From the predicted series $\widehat{x}$ and $\widehat{\varepsilon}$, the Fourier modified series $\tilde{x}$ of series $\widehat{x}$ is determined by:

$$\tilde{x} = \{\tilde{x}(1), \tilde{x}(2), \tilde{x}(3), \ldots, \tilde{x}(k), \ldots, \tilde{x}(n)\} \tag{12}$$

where $\begin{cases} \tilde{x}(1) = \widehat{x}(1) \\ \tilde{x}(k) = \widehat{x}(k) + \widehat{\varepsilon}(k) \quad \left(k = \overline{2, n}\right) \end{cases}$

To evaluate the model accuracy, there are four important indexes to be considered, such as:

1. The mean absolute percentage error (MAPE) [1, 10, 13]:

$$MAPE = \frac{1}{n}\sum_{k=1}^{n} \frac{|x(k) - v(k)|}{x(k)} \qquad \left(k = \overline{1, n}\right)$$

   where v(k) is the forecasted value of entry k from the model.
2. The post-error ratio C [6, 12]: $C = \frac{S_2}{S_1}$

   where: $S_1 = \sqrt{\frac{1}{n}\sum_{k=1}^{n}[x(k) - \overline{x}]^2} \qquad where \quad \overline{x} = \frac{1}{n}\sum_{k=1}^{n} x(k)$

$$S_2 = \sqrt{\frac{1}{n}\sum_{k=1}^{n}[\varepsilon(k) - \overline{\varepsilon}]^2} \ where \quad \varepsilon(k) = x(k) - v(k) \quad and \ \overline{\varepsilon} = \frac{1}{n}\sum_{k=1}^{n}\varepsilon(k)$$

$$S_2 = \sqrt{\frac{1}{n}\sum_{k=1}^{n}[\varepsilon(k) - \overline{\varepsilon}]^2} \quad where \ \varepsilon(k) = x(k) - v(k) \quad and \ \overline{\varepsilon} = \frac{1}{n}\sum_{k=1}^{n}\varepsilon(k)$$

   The smaller the C value is, the higher accuracy the model has.
3. The small error probability P [14, 15]:

$$P = p\left\{\frac{|\varepsilon(k) - \overline{\varepsilon}|}{S_1} < 0.6745\right\}$$

   The higher the P value is, the higher accuracy the model has.
4. The forecasting accuracy ρ [15]: $\rho = 1 - MAPE$

The above four indexes are used to classify the grades of forecasting accuracy as in Table 1.

The historical data of the output values of the bicycle and spare part in Taiwan is obtained from the yearly statistical data published on Global Sherpa [16] from 2000 to 2011. There are totally 12 observations available as stated in Table 2.

All of the calculation in this study is done with Microsoft Excel which offers two useful functions named Mmult(array1,array2) to return the matrix product of two

Table 1 Four grades of forecasting accuracy

Grade level	MAPE	C	P	ρ
I (Excellent)	<0.01	<0.35	>0.95	>0.95
II (Good)	<0.05	<0.50	>0.80	>0.90
III (Qualified)	<0.10	<0.65	>0.70	>0.85
IV (Unqualified)	≥0.10	≥0.65	≤0.70	≤0.85

Table 2 Output values of bicycle and spare parts in Taiwan (Unit: NTD1, 000)

Year	Bicycles	Spare parts
2000	31,893,328	26,972,961
2001	22,447,194	17,603,430
2002	22,240,119	17,080,565
2003	23,790,151	18,084,055
2004	28,865,324	23,356,953
2005	35,047,547	27,741,044
2006	31,528,886	28,381,376
2007	38,983,342	32,614,944
2008	51,222,363	39,129,839
2009	46,318,810	32,659,272
2010	51,435,893	41,910,549
2011	54,690,706	44,891,220

relevant arrays and Minverse(array) to return the inverse matrix. These functions are used to find out the values of parameters in GM (1, 1) and Fourier residual modification.

Data from year 2000 to 2010 are used to establish GM (1, 1); whereas, the output value on year 2011 is used to test for the accuracy level of the FMG (1, 1) before it is applied to forecast the output values in 2012–2015. Once GM (1, 1) model is identified, its forecasted values and residuals are easily obtained. Its residual series is then modified with Fourier series as stated in section 2.2. From the modified series, predicted series under FGM (1, 1) model is calculated as shown in Eq. (12). After that, the predicted series are used to determine the actual residuals from modified models for evaluating its forecasting power.

Finally, the forecasted value of year 2011 under FGM(1,1) is compared with the actual values of year 2011 to find out the accuracy of the forecasting model before it is used to forecast the values in period from 2012 to 2015.

3 Results

3.1 Grey Model GM (1, 1) for the Output Values of Bicycles

From the data of output values of bicycles from year 2000–2010 in Table 2, the coefficients a and b in GM(1,1) are calculated as: a = –0.10271, b = 16,889,227.83

Table 3 Summary of evaluation indexes of model accuracy

Index / Model	MAPE	S1	S2	C	P	ρ	Forecasting power
GM(1,1) for bicycles	0.0603	10,368,370	3,014,227	0.2907	0.909	0.9397	Qualified
FGM(1,1) for bicycles	0.0018	10,368,370	61,426	0.0059	1.000	0.9982	Excellent
GM(1,1) for spare parts	0.0653	8,024,421	2,517,064	0.3137	1.000	0.9347	Qualified
FGM(1,1) for spare parts	0.0263	8,024,421	697,832	0.0870	1.000	0.9737	Good

So, the GM (1, 1) model for the output values of bicycles is written as

$$\widehat{x}^{(1)}(k) = 196,330,892\exp(0.10271\,(k-1)) - 164,437,564$$

The evaluation indexes of this GM (1,1) model are listed in Table 3. The residual series of GM (1,1) is modified with Fourier series as illustrated in the next section.

3.2 Fourier Modified FGM (1, 1) for the Output Values of Bicycles

The residual series of GM (1, 1) obtained in Sect. 3.1 is now modified with Fourier series based on the algorithm in Sect. 2. With this modified series, the forecasted values of bicycles based on Fourier modified model FGM (1, 1) are calculated based on the Eq. (12). The evaluation indexes of FGM (1,1) are listed in Table 3.

3.3 Grey Model GM (1, 1) for the Output Values of Spare Parts

From the data of output values of spare parts from year 2000–2010 in Table 2, the coefficients a and b in GM(1,1) are calculated as: a = –0.09918, b = 13,655,683.29

So, the GM (1, 1) model for the output values of spare parts is written as

$$\widehat{x}^{(1)}(k) = 164,660,547\exp(0.09918\,(k-1)) - 137,687,586$$

The evaluation indexes of this GM(1,1) model are also listed in Table 3. The residual series of this GM(1,1) is modified with Fourier series as illustrated in section 4.4.

Table 4 Actual versus forecasted output values of bicycles and spare parts in 2011 (Unit: NTD1, 000)

	Actual values	Forecasted values	MAPE
Bicycles	54,690,706	59,313,158	0.0845
Spare parts	44,891,220	47,453,292	0.0571

Table 5 Forecasted output values of bicycles and spare parts in 2012–2015 (Unit: NTD1, 000)

	Bicycles	Spare parts
2012	64,370,614	48,502,588
2013	70,613,676	54,322,350
2014	80,617,882	61,833,489
2015	92,533,944	71,769,382

3.4 *Fourier Modified FGM(1,1) for the Output Values of Spare Parts*

The residual series of GM(1,1) obtained above is now modified with Fourier series based on the algorithm in Sect. 2. With this modified series, the forecasted values of bicycles based on Fourier modified model FGM(1,1) are calculated based on the Eq. (12). The evaluation indexes of FGM(1,1) are also listed in Table 3.

Table 3 briefly demonstrates the evaluation indexes of each model of GM(1,1) and FGM(1,1) with its power in forecasting the output values of bicycles and spare parts from year 2000–2010. FGM(1,1) has proved to be better than the conventional Grey model GM(1,1). The MAPE values of 0.18 % and 2.63 % are for the modified models in the case of forecasting output values of bicycles and spare parts, respectively.

Modified model FGM(1,1) is now tested for its accuracy by forecasting the output values in year 2011 which will then be compared with the actual ones for further conclusion. The forecasted output values of bicycle and spare parts in 2011 are illustrated in Table 4.

As the MAPE values of the two forecasting results are 8.45 % and 5.71 %, respectively to the case of output values of bicycles and spare parts, FGM(1,1) is considered good that can be applied to forecast the output values of bicycles and spare parts in the period from 2012 to 2015. The relevant forecasted values are shown in Table 5.

Under assumption that the production facilities are still as good as they are now, the output values of the bicycle and spare part industry are forecasted as in Table 5 which shows that the average annual growth rates of bicycles and spare parts in the period from 2012 to 2015 are respectively about 12.86 % and 13.95 %. In comparison to the huge opportunities opening up for Taiwan bicycles and spare parts after the Economic Cooperation Framework Agreement (ECFA) between China and Taiwan came into effect in 2010 as well as other free trade agreements that Taiwan did and will achieve, the growth rates are considered rather small. Therefore, if there is no significant investment in the manufacturing technology and/or facilities, Taiwan bicycle and spare part industry will not be able to seize the opportunities for a sustainable development.

4 Conclusion

The indexes in Table 3 clearly show that the conventional GM(1,1) gain much higher accuracy once its residuals are modified with Fourier series. In the case of the output values of bicycle and spare parts in Taiwan, FGM(1,1) is a strongly suggested forecasting model due to its high accuracy level. Highly precise forecasting result will help the policy-makers and related organizations in the relevant industry in Taiwan to have proper planning and strategies for the industry.

Fourier residual modification has been successfully applied to enhance the accuracy of the fundamental form of Grey forecasting model GM(1,1). This good approach should be also applied to other forecasting models.

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Flexible Simulation Model for Multi-style Shoes Manufacturing: A Case Study

James C. Chen, A.P. Putra, N. Anggono, K.J. Wang, S.W. Lin, and C.C. Chen

Abstract Emerging need of shoes manufacturing that is smaller in number but has more variety has encouraged factories to encompass more styles of shoes in one production cycle. A simulation model was built to enable assessment of style addition to a production facility. To do so, the model has to be able to accommodate changes between style numbers. This study proposes a global arrangement for stations, as opposed to station-based simulation profiling, in order to ease switches between style numbers. To further see model's behavior, the model is tested under small and large number of shoes styles. The result shows that the model can be used with various style numbers. Using the differences obtained through selected parameters, deployment of production with different number of shoes styles can be assessed.

Keywords Multi-style shoes manufacture • Production • Simulation

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1 Introduction

Fashion-related industry has seen the fast-changing trend of customers demand for quite some time now. Brands need to react fast, manufacturers need to keep up. They are compelled to do their production with less volume, but bigger variety. With such pace, producing goods like clothing and shoes is especially a challenge for the labor intensive industry. Once new models/styles/designs are introduced, they must alter the current production setting, disseminate it to the workers, and have it deployed. Management of a production facility should know its capability and features – whether or not a new design can be produced in there and how to do so. However, with the high rate of changes, new setups are often found to be in need of change after deployment due to lengthy production time, idle or overworked stations, or mazy routing. Field research has indicated that higher level of information asymmetry is to be expected in flexible production environment, leading to the need of more financial control [1]. Flexibility of production, particularly the increase in number of styles to produce, also means more cost in production [2]; daily production rate decreases and cycle time is lengthened. Hence, a setup must first be assessed to ensure its effect on production. In this paper, a simulation-based testing that can accommodate changes when a new style is added into a facility is proposed. This differs quite substantially from generic models, which are meant to accommodate basic process logic of certain simulation genre and be used in a range of instances, despite the specific sets of characteristics (layout, machinery profile, etc.) every model has [3].

Another ground of this motion is the rising wage rate in countries where shoes manufacturer do their production. Foreign competition was the reason why countries like United States must aim for lower productivity but better profit and cut slacks anywhere possible in order to stay in business [4]. A lot of production processes were eventually moved to countries with lower wage. Lately, these destination countries have been prepared for higher bargain. Western companies are said to have exploited the low wage and employed the low-income labors under horrific conditions [5]. Public – the ultimate customer of the industry – demands that labor cost, which is typically a tiny fraction of the retail price, be paid more reasonably. Although such pressure provides the incentive of relocating production, many decided that keep moving location was not the answer – limited choices of location and the cost of moving being some of the reasons. The latter must then cut down the wage threat by decreasing the number of employment. This situation complies with the need of smaller production quantity. Medium-sized facility is thus the alternative chosen by the manufacturer in this case study, meant as a preliminary study for future facility.

Previous works related to this study vary in terms of scope/focus, industry, and simulation tool. Chen et al. [6] used simulation to evaluate production policy in color-filter fabrication facilities – fabs – using AutoMod. Chen et al. [7] built a model of existing color-filter fabs to develop and assess a look-ahead release plan.

Similar flexible fashion was proposed by Angerer et al. in their Matlab/Simulink simulation for RFID performance evaluation with different protocols [8]. Simulation to assess the impact of new product introduction due to shift in demand was found in IC manufacturing [9]. Given its automated and complex nature, high-technology manufacturing is more reluctant to change. The prevalent need is hence to have a test bed for extensive operational analyses prior to real implementation. Greasley [10] conducted a case study to estimate the size of storage areas required for a proposed overseas textile manufacturing facility. The discrete simulation model made in ARENA was able to show queuing behavior and provide qualitative understanding of it, proving to be beneficial for the facility development. Managerial decision related to engineering lots that uses the same resource as production lots in wafer fabrication facilities was discussed in Crist and Uzsoy [11]. The paper argues that such engineering lots can affect a facility's overall performance, notwithstanding its production capacity. It also implies that prioritization policy in the fabs' production activity should align well with engineering needs/organization, especially the level of available engineering resource, hinting the possible existence of factors outside the original variables found after simulation.

2 Methodology

Given the complexity of manufacturing process, simulation is a suitable method for the study. Complexity factors such as multiple part types processed in the same line, hundreds of manufacturing steps and multiple level of subassemblies can be found in it. The steps taken are adapted from a paper written by Law [12]. The main objective of this study is to build a simulation model that allows modification related to shoes style numbers and exhibits dissimilarity among modifications. Having known the problem, data related with the projection of facility was elicited from the client. Collected data includes stations, processes and their duration, and projected output rate. The author then proceeded with model building, in which the simulation tool Flexsim [13] was used, followed by validation, simulation, result analysis, and documentation. The flow of these stages is illustrated in Fig. 1.

Regular interaction with client in the form of interview and observation accompanies the process of data collection and model building. Model validation was done by comparing output levels to projection based on existing larger facility. One of the benefit of using simulation is its capability to profile scaling – study of larger or smaller version of a system [14]. Model behavior and result were also consulted with personnel from client's company to complete the validation. The aim of this study is, instead of external validity, being a reliable exemplary attempt – repeatable with similar benefits [15]. Underlying concepts and logic related to simulation and result analysis are taken from Law [16].

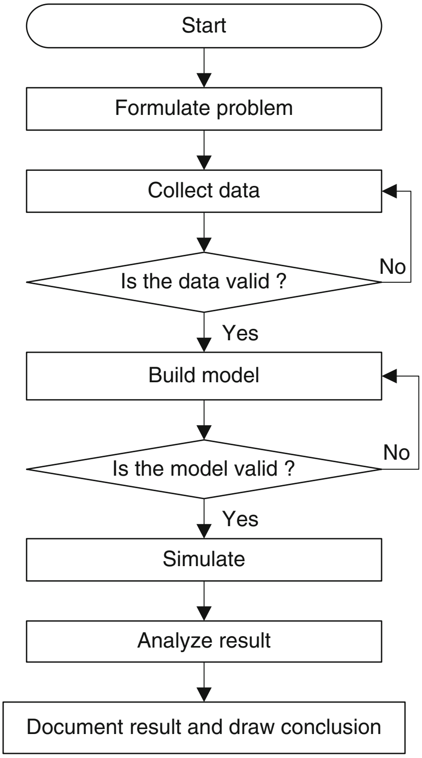

Fig. 1 Flowchart of stages performed in the study

3 Case Study

This study is focused on processes of upper-part of shoes. The design of projected facility is divided into four working areas. Production lines are located on the three out of those four working areas. In total, there are 12 production lines – each of them consists of its own cutting, preparation, stitching and assembly working area. The other working area is used for secondary processes, which is part of preparation processes and used together by all production lines.

The production steps are similar to common processes of shoes manufacturing [17–19]. The first step is cutting the materials of shoes part. Then, most of those cut materials need to go through a series of processes called preparation processes. Some of them also need to be cut again, so the flow may be back and forth between workstation of cutting and preparation processes. All of processed parts will go to waiting area. Once the part of a shoe is complete, it will be stitched to form the upper part of the shoes. After that, upper parts will be sent to assembly area to be assembled with shoes bottom and other accessories. The process of shoes manufacturing is illustrated in Fig. 2.

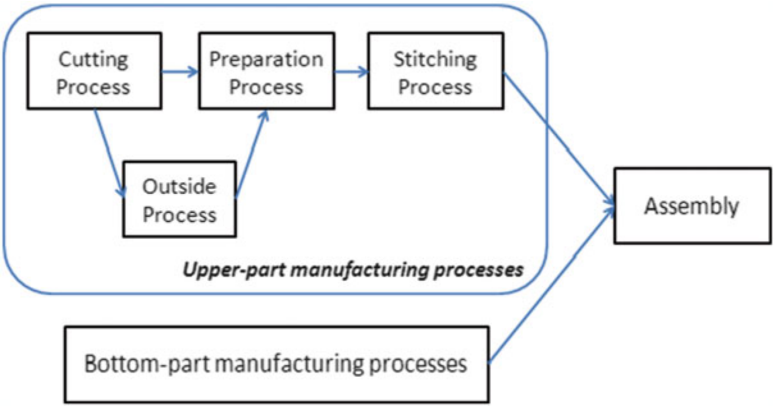

Fig. 2 Shoes manufacturing process

3.1 Cutting

All of sheet-shaped materials are cut during this process. In one cutting line, the processing time may be different due to variety of processed parts. The cutting process is done per batch, where one batch consists of 80 pieces.

3.2 Preparation

The idea of preparation step is to conduct several processes that enable the cut materials ready to be stitched together with other parts. Example of this processes are: marking, peeling, gluing, depletion and heating. Those processes are conducted on each production line. Some of preparation processes are grouped together into what is called secondary processes. Secondary processes include embroidery, high-frequency process, fuse, screen printing, digital printing, laser engraving, and some other processes. Unlike the other preparation processes, secondary processes have their own area, separated from production lines, which is used together by all production lines. During its production, every part of shoes may go through several steps included on the preparation processes. Preparation processes are also done per batch of 80 pieces.

3.3 Waiting Area

This area is located in every production line, connecting preparation and stitching. It acts as collecting area of shoes parts from the cutting and preparation area. Parts will be passed on to stitching process after all required ones are complete.

3.4 Stitching

This process aims to assemble all of parts collected on the waiting area to form the upper part of the shoes. Each production line has its own stitching area and the process is done per item.

3.5 Assembly

In this last step, upper part is assembled with bottom and other accessories to form a finished shoe. This step is mostly conducted in a belt conveyor and includes some processes such as gluing, heating, and joining.

4 Simulation Study

The data for building the simulation model is based on existing large-scale shoes factory that owned by the company. The simulation model was built using Flexsim 5.1.2. It includes 3 shoes style that produced on 12 planned production lines. The view of the model is shown in Figs. 3 and 4. The factory consists of four main areas, three of them are production lines (grey area) and the rest one is secondary

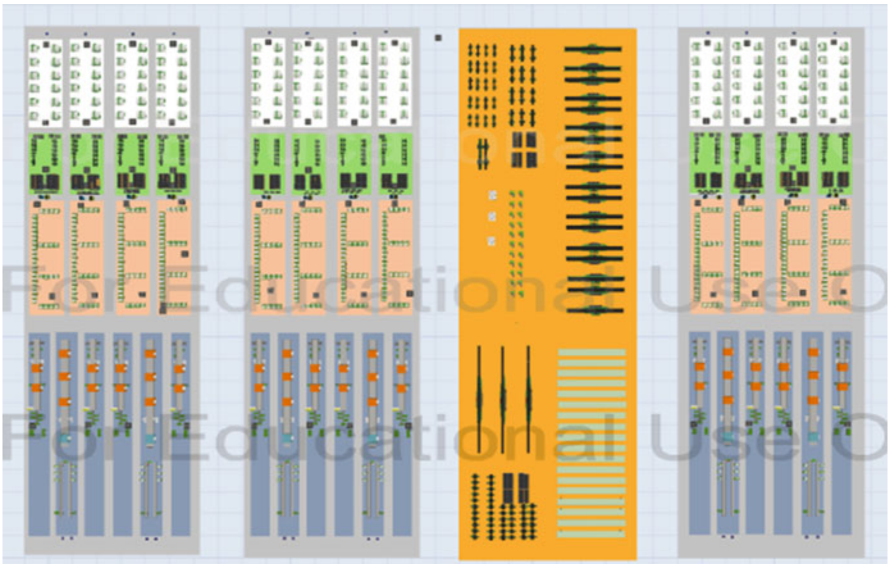

Fig. 3 Simulation model for proposed medium-sized shoes factory (1)

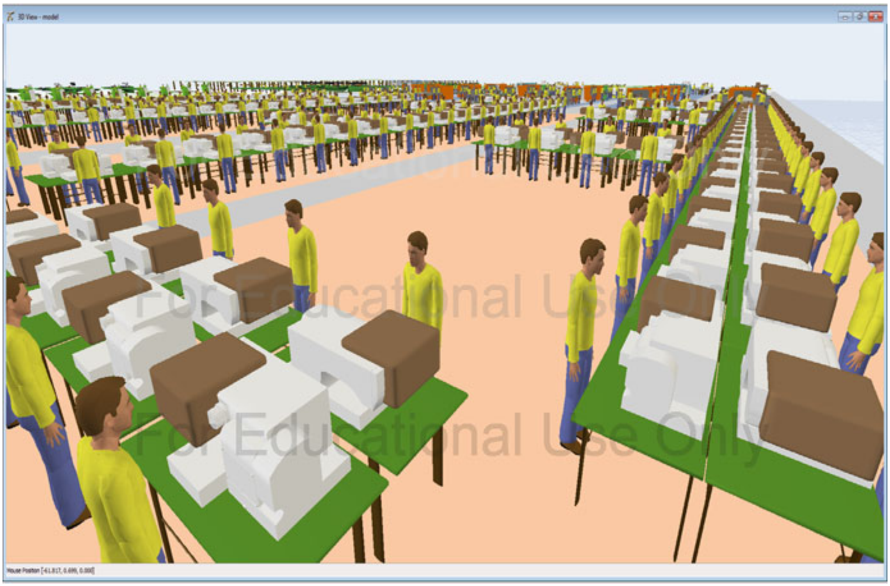

Fig. 4 Simulation model for proposed medium-sized shoes factory (2)

processes area (orange area). Production lines are divided into four smaller areas which are cutting, preparation, stitching and assembly area which are marked by white, green, beige and blue respectively.

There are some assumptions used in the model – all have been consulted with the client. They include no labor involvement, no material handling, no reject products, continually available machine, and first-come-first-served rule. Outside process is treated as black-box process, but its processing time is still considered. For the assembly process, we assume other parts that need to be assembled with upper-parts (e.g. bottom-parts, accessories) are always available.

Due to the nature of shoes factory to periodically changes shoes styles, Flexsim's feature of Global Table is used to create a simulation model that is flexible enough to this behavior [20]. It is done be inputting the routing of each shoes style and also processing time of corresponding machines to Global Table. Machines are set to look at Global Table in order to determine flow item's processing time by detecting the item type of the flow item. For the routing, a Queue object is used to send the flow item to corresponding nodes by referring to Global Table. Therefore, whenever the change of shoes style is needed, adjustment of production routing and processing time can be done through editing the Global Table. There is no need to open and edit simulation's object one by one.

The model was run for 7 days with initial warming-up period of 21 days in order to reach the steady state (1 day equals to 8 working hours). Model validation was done by confirming with clients and comparing output of the model with the expected output according to specified factory design, which are 1,000 pairs per day/production line.

Table 1 Results comparison between 3-styles and 12-styles simulation model

Parameters (daily-based)	3 styles	12 styles
Average output	1,023.42	901.9
Avg. machine utilization		
Embroidery	91.55 %	86.65 %
Screen printing	18.68 %	100 %
High frequency	91.35 %	38.89 %
Average queue		
Embroidery	6.93	0.07
Screen printing	0.046	102.5
High frequency	0.38	0

In order to see the behavior of the system under various models, additional 9 shoes style is added to the model. It brings total 12 shoes styles to the model, with each style produced on each production line. The addition of styles is done by modifying the routing and processing time data on designated Global Table. Comparison between these two experiments is shown on Table 1. The comparison parameters are average output, average machine utilization and average number of queue. For the last two parameters, the data are taken from three major processes which are classified as secondary processes. The reason is, because resources on secondary processes are used together by all production lines. Therefore, those processes are clearly affected by variations of the produced shoes style.

The experiment result shows that variation of shoes styles will have effect on the projected factory. It can be seen that more styles variations is lowering the production output, in this case from 1,023.42 down to 901.9.

Machine utilization and number of queue may be higher or lower. It is reasonable as the simulation model is originally set for initial 3 shoes styles. After the addition of 9 shoes style, some processes might be under or over utilized, depending on the processing steps needed to finish those shoes styles. But in this case, the increase of machine utilization and number of queue tend to have more effect, i.e. lower output. This finding complies with what has been stated by Eryilmaz [2].

5 Discussion

Based on what have been done, the built model is able to facilitate easiness when changing of shoes styles is needed. As the routing and processing time between one and other shoes styles is different, usually it takes longer to manually connect different simulation objects in order to change the routing or to change machine's processing time one by one. In the experiment, changing the simulation setting from initial 3-styles to 12-styles took just about an hour. However, additional concern was identified through the experiment. As previously mentioned, the simulation model could not reach the daily target of 1,000 pairs per production line. It is understandable as the model setting is specified for only 3 styles, with changes in routing and processing time. To cope with this condition, another adjustment should be proposed and added to the model: production capacity.

Adjusting production capacity is almost definitely needed whenever number of shoes styles is changed. With the same process/station, different shoes styles can have different processing time. Hence, it will affect the production capacity. In details, production capacity can be translated into smaller parameters such as working hours, machine capacity, number of machine, number of operator, etc. Which parameters are to be concerned is different from one case to another, depending on client's request. In this case study, production capacity for secondary process is crucial as this area is used together by all production lines. It means that the production capacity of this area is harder to determine. Therefore, future work is tightly related to this issue.

6 Conclusion

A flexible simulation model was created to assist the assessment of medium-sized shoes manufacturing facility. The model is able to ease the process of changing produced shoes styles such that management can decide how many styles should be produced concurrently. The model was built using Flexsim 5.1.2. The use of global table feature in the organization of routing and processing time, in contrast to station-based profiling is the key feature in this study. Experiment with the model has been done by running the model using 3-styles and 12-styles of shoes. The result shows that different styles do affect the output of the system, as well as machine utilization and queue.

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A Forecasting Model for Short Term Tourist Arrival Based on the Empirical Mode Decomposition and Support Vector Regression

Jun Wang, Ming-ming Hu, Peng Ge, Pei-yu Ren, and Rong Zhao

Abstract In this study, a hybrid forecasting model based on Empirical Mode Decomposition (EMD) and Least Squares Support Vector Machines (LSSVMs) is proposed to predict tourism demand (i.e. the maximal number of arrivals in a short time interval). The proposed approach first uses EMD decompose the complicated data into a finite set of Intrinsic Mode Functions (IMFs) and a residue, then the IMF components and residue are modeled and forecasted using Least Squares Support Vector Machines, next, the forecasting values are obtained by the sum of these prediction results. In order to evaluate the performance of the proposed approach, the maximal values of tourist arrive in 1 min time interval is used as an illustrative example. Experimental results show that the proposed model outperforms the single LSSVM model without EMD preprocessing.

Keywords Empirical mode decomposition • Forecasting • Least squares support vector machine • Tourist arrival

1 Introduction

Over last five decades, international tourism has experienced an overwhelming boom, and the world tourism has grown from a mere 69.3 million international tourist arrival in 1960 to 935 million in 2010, with an average growth rate of 5.3 % per year [1]. Especially, in China, according to data from the Tourism Bureau of Republic of China (ROC), taking the National Day holiday for instance, the tourism kept increasing rapidly in 2012 with more than 300 million tourists and rose as

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high as 17.5 % compared with the same period of the previous year. Evidently, the continually increasing number of tourists will definitely bring huge pressure to the scenic managers.

Therefore, a great number of scholars devoted themselves to the research of tourism demand analysis and forecasting over the last decades, for accurate forecasting of tourist arrival and the study of the tourist arrival patterns are essential for the scenic managers to formulate efficient and effective strategies on scenic management. Chen [2] combined the linear and nonlinear statistical models to forecast time series with possibly nonlinear characteristics. Chu [3] constructed and used a piecewise linear method to model and forecast the demand for Macau tourism, Kim [4] evaluated the performances of prediction intervals generated from alternative time series models, Andrawisa [5] constructed a tourism demand forecasting model which combines long term and short term, and many scholars have also turned to nonlinear methods such as the neural network [6–9] and support vector regression (SVR) models [10, 11] for tourism demand forecasting. Hong et al. [12] proposed hybrid model to predict tourism demand forecasting, which combines support vector regression and chaotic genetic algorithms.

Although those literatures have brought enormous interest for both academics and practitioners, however, most of those studies forecasted tourism demand in a long term, but few researches discussed tourist arrival in a short term, such as 10–30 min. Nevertheless, short-term tourist arrivals forecasting is a vital component of scenic systems. The forecasting results not only can support scenic managers to make previous operation planning, scenic spot crowd regulation planning, and real-time scheduling of tour buses in the scenic area, but also enhance the service quality.

This paper aims to analyzing the time variants of short-term tourist arrival in a scenic system by a hybrid model using Empirical Mode Decomposition and Least Squares Support Vector Machine. The remainder of this paper is organized as follows. Section 2 gives the framework of the hybrid model. Sections 3 and 4 give the introduction to the concept and algorithm of EMD and LSSVM. Section 5 introduces the data of tourist flow, obtains the forecasting result by the hybrid model, and compares the results between hybrid method and LSSVM. Finally, Sect. 6 concludes this paper.

2 Framework of EMD and LSSVM Hybrid Model

Suppose we have a real valued time series $X = \{x(t), t = 1, \cdots, n\}$, i.e. the historical values of the series. When other variables which can affect the series x are not given, the task is to predict $x(n+k)$ with $k > 0$, based on the historical values. In other words:

$$x\left(n+k\right) = f\left(x(n), x\left(n-1\right), \ldots, x\left(n-\left(l-1\right)\right)\right), k.l > 0 \tag{1}$$

The usual way to make the prediction is to find an appropriate l and a function f, which describes the relation between l consecutive elements and the next element of the series. Here, l denotes the historical window size and k represents the horizon of the future [13]. For the stationary time series, there are several sophisticated methods can cope with it, nevertheless, most of the time series we confronted with are nonlinear and non-stationary, therefore those traditional methods are infeasible.

Fortunately, EMD model can well behaved to decompose the nonlinear and non-stationary time series into a number of subseries, which are relative stationary. On the other hand, the goal of SVM regression is to estimate a function that is as 'close' as possible to the target value for every input value and at the same time, is as 'flat' as possible for good generalization. And the function is represented using a linear function in the feature space [14].

Therefore, it is a good idea to predict non-stationary time series by combing both the advantages of EMD and SVM. And in this paper, we select the LSSVM for regression. Then, the framework of EMD & LSSVM hybrid model is demonstrated in Fig. 1. The detailed calculation steps are described as follows.

1. Apply the EMD to decompose an original time series $x(t)$ into a set of different sub-series, namely the Intrinsic Mode Functions (IMF) $c_j(t)$.
2. Use the LSSVM to build a forecasting model for the each subseries, and make the forecasting in the each subseries.
3. Conduct aggregate calculation for the predicting results in the sub-series to attain the final forecasting.

3 Empirical Mode Decomposition

Empirical mode decomposition (EMD) can deal with non-linear and non-stationary data, which is a nonlinear signal transformation method developed by Huang et al. [15]. It is used to decompose original time series data into a sum of intrinsic mode function (IMF) components with individual intrinsic time scale properties, which must satisfy the following two conditions:

1. In the whole data set of a signal, the number of extreme and the number of zero crossings must either equal or differ at most by one, and
2. At any point, the mean value of the envelope defined by the local maximal and the envelope defined by the local minimal is zero.

The essence of EMD is the sifting process which extracts IMFs from the original data. The algorithm of EMD is described as follows:

Step 1: Identify all the local extreme including minimum values and maximum values in time series data $x(t)$,

Step 2: Obtain the upper envelope $x_u(t)$ and the lower envelope $x_l(t)$ of the $x(t)$,

Step 3: Use the upper envelope $x_u(t)$ and the lower envelope $x_l(t)$ to calculate the first mean time series $m_1(t)$,

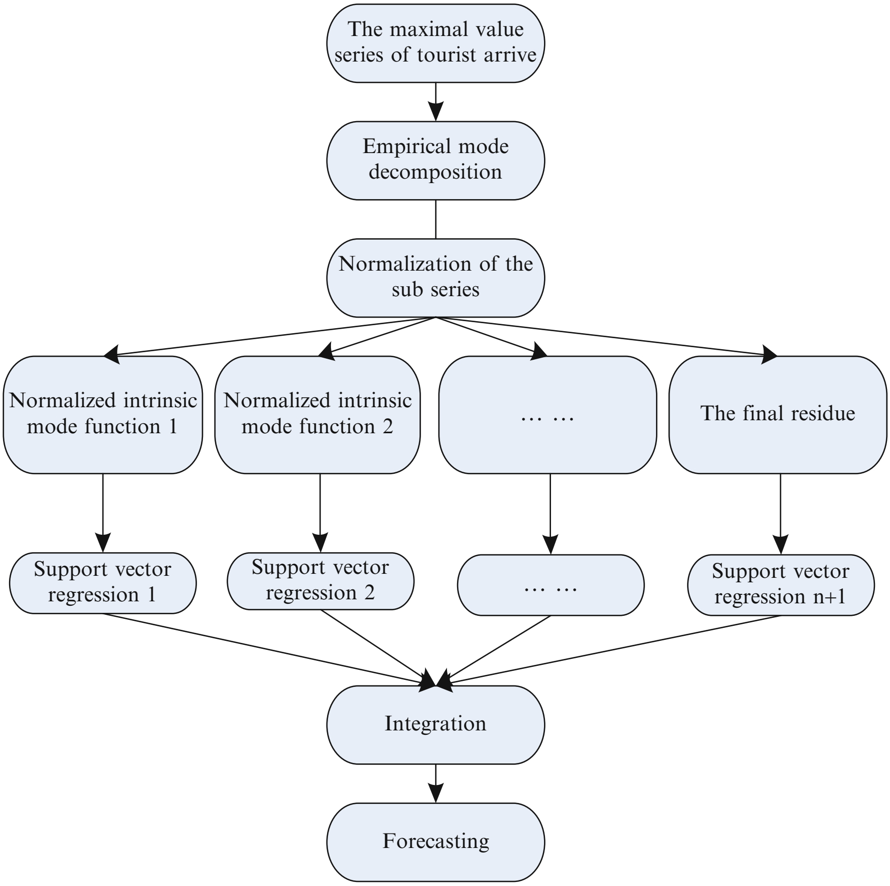

Fig. 1 The flow diagram of the hybrid EMD-SVM model

$$m_1(t) = (x_u(t) + x_l(t))/2, \tag{2}$$

Step 4: Evaluate the difference between the original time series $x(t)$ and the mean time series $m_1(t)$, and get $h_1(t) = x(t) - m_1(t)$.

Step 5: Check whether $h_1(t)$ satisfies the above two conditions of an IMF property or not. If they are satisfied, $h_1(t)$ should be an IMF, and $h_1(t)$ is denoted as the first IMF $c_1(t)$, and substitutes residue $r_1(t)$ for the original time series data $x(t)$, where

$$r_1(t) = x(t) - h_1(t). \tag{3}$$

Otherwise, $h_1(t)$ is not an IMF. Then, it substitutes $h_1(t)$ for the original time series $x(t)$.

Step 6: Repeat Step 1–5. The sifting process stops when the residue satisfies one of the termination criteria. First, the residue or the i-th component is smaller than the predetermined threshold or becomes a monotonic function such that no more IMF can be extracted. Second, the number of zero crossings and extreme is the same as that of the successive sifting step.

By using the above algorithm, the original time series data $x(t)$ can be decomposed into n modes and a residue as follows:

$$x(t) = \sum_{j=1}^{n} c_j(t) + r_n(t), \tag{4}$$

where n is the number of IMFs, $c_j(t)$ represents IMFs which are nearly orthogonal to each other and periodic, and $r_n(t)$ is the final residue which is a constant or a trend.

4 Support Vector Machine

The regression with support vector machine [16] is based upon the idea to deduce an estimate $f(x)$ of the true y and unknown relationship $y = f(x)$ between the vector of observations x and the desired y from a given set of training samples. This is usually performed by mapping the data from the original feature space to a higher dimensional transformed feature space, to increase the flatness of the function and, accordingly, to approximate it in a linear way as follows

$$f(x) = \omega^T \varphi(x) + b \tag{5}$$

Where $x \in R^n, f(x) \in R$ and $\varphi(x)$ denotes a set of nonlinear transformation. Then, the object function is defined as follows

$$\min J(\omega, e) = \frac{1}{2}\omega^T \omega + \frac{1}{2} C \sum_{i=1}^{l} e_i^2 \tag{6}$$

Which is subjected to the equality constrains

$$y_i = \omega^T \varphi(x_i) + b + e_i, i = 1, 2, \ldots, l \tag{7}$$

where C is the regularization parameter that balances model complexity and approximation accuracy, and e_i is the error between the actual output and the predictive output of the i-th sample.

The corresponding Lagrangian is given by:

$$L(\omega, b, e, a_i) = J(\omega, e) - \sum_{i=1}^{l} a_i \left(\omega^T \varphi(x_i) + b + e_i - y_i\right) \tag{8}$$

Where a_i are the Lagrange multipliers. According to the Karush–Kuhn–Tucker conditions of Eq. (8), we can get

$$\begin{cases} \dfrac{\partial L}{\partial \omega} = 0 \Rightarrow \omega = \sum_{i=1}^{l} a_i \varphi(x_i) \\ \dfrac{\partial L}{\partial b} = 0 \Rightarrow \sum_{i=1}^{l} a_i = 0 \\ \dfrac{\partial L}{\partial e_i} = 0 \Rightarrow a_i = C e_i \\ \dfrac{\partial L}{\partial a_i} = 0 \Rightarrow \omega^T \varphi(x_i) + b + e_i - y_i = 0, i = 1, 2, \ldots, l \end{cases} \tag{9}$$

After eliminating e_i and ω the following linear equation set is obtained:

$$\begin{pmatrix} 0 & 1_l^T \\ 1_l & \Omega + C^{-1} I \end{pmatrix} \begin{pmatrix} b \\ a \end{pmatrix} = \begin{pmatrix} 0 \\ y \end{pmatrix} \tag{10}$$

Where

$1_l = (1,1, \ldots,1)^T_{1\times l}$, $a = (a_1,a_2, \ldots,a_l)^T$, and $y = (y_1, y_2, \ldots,y_l)^T$. The Mercer's condition is applied within the matrix $\Omega = \{\Omega_{ij}\}_{l\times l}$ as follows and $I_{l\times l}$ is a identity matrix.

$$\Omega_{ij} = \varphi(x_i)^T \varphi(x_j) = K(x_i, x_j) \tag{11}$$

Then the resulting LS-SVM model for regression becomes

$$f(x) = \sum_{i=1}^{l} a_i K(x_i, x_j) + b \tag{12}$$

In Eq. (12), there are several different kinds of Mercer kernel function $K(x, x_i)$ such as polynomial, sigmoid, and radial basis function (RBF). Because of fewer parameters to set and an excellent overall performance, the RBF is an effective option for kernel function. Therefore, this study applies an RBF kernel function, showed as Eq. (13), to help the LSSVM regression model in obtaining the optimal solution.

$$K(x, x_i) = \exp\left(-\|x - x_i\|^2 / 2\sigma^2\right). \tag{13}$$

5 Case Study

JiuZhai Valley is one of the most famous scenic areas in China, which has attracts tourists from all over the world, hence, it is imperative for the managers of the scenic area to forecast the peak value of tourists' arrivals to provide with corresponding personnel and equipment so as to eliminate tourists congestion at the entrance of the scenic areas and enhance the service ability of the administering authority.

In this study, the maximal tourists' arrivals in each short time interval (1 min) of every day in JiuZhai Valley from Jan 1th to Dec 31th, 2009, are used, which are obtained from the gate control system of JiuZhai Valley. In this application, the history data set has been divided into two subsets, which are used for calibration and testing respectively.

5.1 Data Analysis

As affected by season, temperature, holidays as well as some other random factors, the fluctuation the tourist number of each day is significant. Naturally, these factors will also definitely result in the significant fluctuation of the peak value of the tourist arrivals. The maximal tourist arrival in a short time interval (1 min) from Jan 1th to Dec 31th in JiuZhai Valley in 2009 is represented in the following Fig. 2.

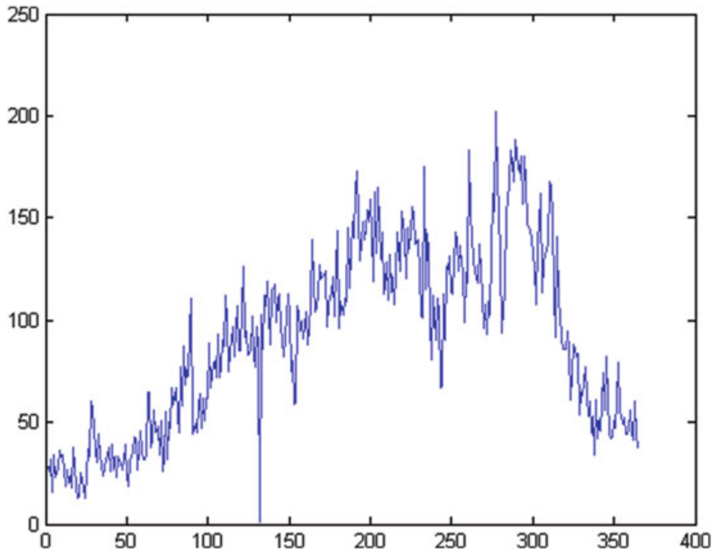

Fig. 2 The peak value of the tourist arrivals from Jan 1st to Aug 31th in JiuZhai Valley in 2009

From the Fig. 2, we observe that the maximal tourist arrive is nearer to zero at Mach 10th. It is indicated that the collected data is incomplete, there is a missing data at Mach 10th. Then, the moving average algorithm is applied to supplement the missed data.

Additionally, in the Fig. 2, we can easily identify that this time series is not a stationary data series. Obviously, the (classical) method such as ARIMA is not suitable for this problem directly. So the time series will be decomposed into a number of independent IMFs and one residue component by EMD.

5.2 EMD of the Peak Value of the Tourists' Arrival

During the EMD process, endpoint data are vulnerable to the impact of border effect due to the length of the actual data series is limited. In order to eliminate boundary effect of the data series, it is necessary to conduct data preprocessing. There are some of common approaches, such as zero boundary method, symmetric extension method, similar extension method and the trend extended boundary method can effectively deal with this problem, here, we select symmetric extension method to process border data, and solve overshoot and undershoot phenomenon.

Suppose the original data sequence is $X = (x_1, \ldots, x_n)$, then the n points forward extension sequence $\overleftarrow{X} = \left(\overleftarrow{x}_1, \ldots, \overleftarrow{x}_n\right)$ can be obtained as $\overleftarrow{x}_i = x_{n-i+1}$, and the n points backward extension sequence $\overrightarrow{X} = \left(\overrightarrow{x}_1, \ldots, \overrightarrow{x}_n\right)$ can be obtained as $\overrightarrow{x}_i = x_{n-i+1}$, where $i = 1, \ldots, n$. Thus we can obtain a time sequence that the length is three times of original time series.

Then, by using EMD, the extended time series is decomposed into seven IMF components and a residue as shown in Fig. 3, whose frequency bands ranging from high to low respectively. The residual component maintains the original shape of the curve of whole time series. It is obvious that the signal on the different levels reflects the different fluctuation characteristic of tourist arrives in a short time interval.

In addition, in the following calculation, there is no necessary to utilize all the data series of each IMFs, but just the middle part of the IMFs.

5.3 LSSVM Training and Forecasting

Before training the LSSVM, each of the components should be normalized to avoid training errors caused by sample data dimensions or extreme values. The normalized formula is

$$\tilde{x} = \frac{x_i - x_{\min}}{x_{\max} - x_{\min}} \tag{14}$$

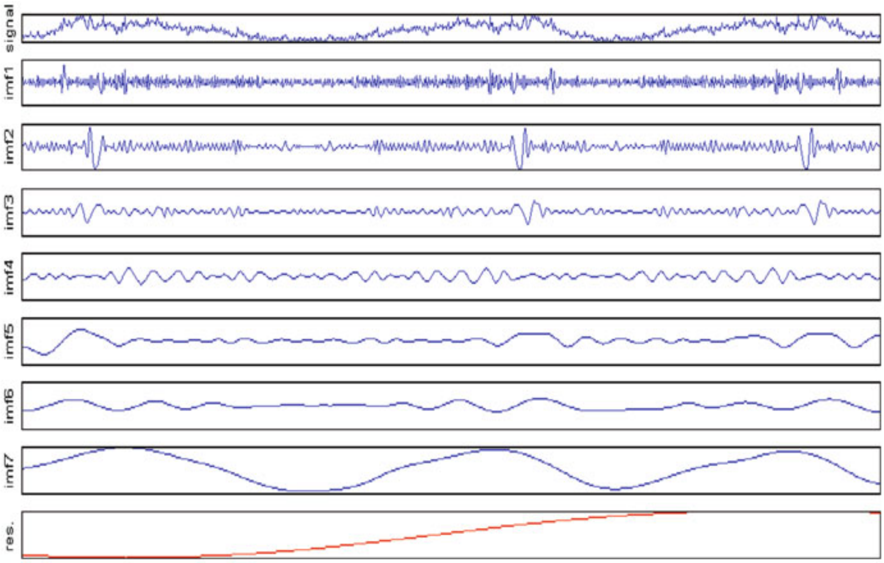

Fig. 3 The decomposition result of the extended series by EMD

Where $\tilde{x}_i$ is the i-th normalized value of the data series, x_i is the i-th value of data series, $x_{\max}$ and $x_{\min}$ are the maximum and the minimal value of the sample series.

After normalization, the input and the output of the training set of each IMFs should be determined. According to Eq. (1.1), we take the l consecutive history data as input variable and the $n+k$ data is considered as output, see Table 1. However, the number of time lags l and the forecast horizon k play significant roles to enhance the perdition accuracy. Since, if the time lags are too large, the forecasting model responds slowly to the fluctuation of tourist flow. On the contrary, if the lag time is too small, the forecasting model overreacts to the fluctuation of tourist flow. Generally, the partial autocorrelogram of these normalized IMFs can be used to determine the time lags l and the forecast horizon k. Nevertheless, in the forecasting process, with the variation of the training set, the number of the IMFs resulting from the training set is different. Therefore, it is infeasible to determine the time lags and the forecast horizon of each IMFs constantly by using the history data. In this situation, some data experiments become important. And the two common criteria RMSE (root mean square error) and MAE (mean absolute error) are adapted to evaluate the experiments result [17].

Due to the effectiveness of seasonality, the future tourist arrive is highly correlated to the recent history data, in order to eliminate the slowness of the responds of forecasting, we take 30, 45, and 60 (1 month data to 2 month data) as the length of the training set. And we also take 3–6 as the time lags, 1–5 as the forecasting horizon respectively. According to the empirically selected parameters, 100 data have been forecasted and the corresponding experimental results are shown in Table 2.

Table 1 The input and the output of training set of the i-th IMF

Input	Output
$x_1^{(i)}, x_2^{(i)}, \ldots, x_l^{(i)}$	$x_{l+h+1}^{(i)}$
$x_2^{(i)}, x_3^{(i)}, \ldots, x_{l+1}^{(i)}$	$x_{l+h+1}^{(i)}$
……	……
$x_{L-l-h}^{(i)}, x_{L-l-(h-1)}^{(i)}, \ldots, x_{L-h-1}^{(i)}$	$x_L^{(i)}$

L the length of the training set of each IMFs, l the time lags, h the forecast horizon

From Table 2, we can observe that (a) when the length of the training set is 30, the corresponding average MAE of different time lags and forecasting horizon is 11.49, which is smaller than the other two situation (the length of training set is 45 and 60). (b) In addition, taking the length = 30 into consideration, with the increasing of the value of the forecasting horizon, the performance criteria MAE and RMSE are almost reduced while taking different time lags. But when taking the forecasting horizon equal to 5, these two criteria begins to increase. (c) Furthermore, although we can easily find that when time lags is equal to 5 the MAE reaches the minimum with forecasting horizon is 4, however, the average of MAE and RMSE are minimal at the same time when taking lag = 5.

Therefore, based on the training and experiment process, we select that the length of training set is 30, and we employ the 6 prior consecutive data as inputs and take the 5th day value as output. The specific steps of the forecasting by EMD & LS_SVM method as follows:

(1) Apply EMD on the first 30 data set S,
(2) Train the EMD & LS_SVM model,
(3) Use the EMD & LS_SVM model to do prediction,
(4) Add the 31 data into the set S and delete the first data,
(5) Repeat step (2) and (3) to get prediction,
(6) Repeat step (4) with a new EMD calculation and continue until 330 data.

In order to evaluate the performance of the proposed forecasting method, we take 330 data for prediction, and apply the LSSVM method as the benchmark. For accuracy purposes, different forecasting horizon value (=1, 2, 3, 4, 5) is also adapted, and the forecasting result is obtained by LS-SVMMlab Toolbox, which are listed in Table 3.

Through the test, we find that the EMD&SVM model can be better preformed than the LLSVM. From Table 3, we can obtain that the performance criteria MAE and RMSE get the minimal value 15.84 and 21.40 respectively with the prediction horizon taking as 4. Meanwhile, the corresponding accurate value and the forecasting value of the 330 data are shown in the following Fig. 4.

Table 2 The performances of the EMD&LSSVM model with different parameters

LT	LP	FH	MAE	RMSE	MAE	RMSE
30	100	Lags = 3			Lags = 4	
		1	12.40	16.35	12.37	15.89
		2	12.95	17.77	11.51	15.40
		3	11.26	14.81	10.69	14.78
		4	11.07	14.64	10.78	14.88
		5	11.02	15.38	11.81	15.16
		Lags = 5			Lags = 6	
		1	12.49	16.25	11.82	15.50
		2	11.33	14.96	10.97	14.21
		3	11.31	15.42	11.25	14.70
		4	10.60	14.83	10.94	14.56
		5	11.42	15.23	11.76	16.04
45	100	Lags = 3			Lags = 4	
		1	12.65	15.83	13.02	16.36
		2	12.44	16.03	12.73	16.14
		3	12.73	15.98	12.85	15.84
		4	12.64	16.48	12.15	15.46
		5	12.56	16.14	13.05	16.12
		Lags = 5			Lags = 6	
		1	12.77	16.03	12.96	16.17
		2	12.40	15.42	11.94	14.95
		3	12.32	15.29	12.87	16.11
		4	12.76	16.01	12.40	15.52
		5	12.71	15.95	12.22	15.32
60	100	Lags = 3			Lags = 4	
		1	13.54	17.27	14.53	18.38
		2	13.78	17.35	13.51	16.94
		3	14.50	17.74	13.96	17.67
		4	14.13	18.35	13.34	16.89
		5	14.56	18.26	13.63	16.97
		Lags = 5			Lags = 6	
		1	14.23	18.59	13.98	17.69
		2	13.60	17.18	13.61	16.89
		3	14.44	17.93	13.51	17.08
		4	13.18	16.41	13.26	16.74
		5	13.70	17.23	13.25	16.78

LT the length of training set, *LP* the length of the prediction set, *FH* forecasting horizon, *Lags* time lags

6 Discussion

In this paper, we propose a hybrid forecasting model based on empirical mode decomposition and Least Squares Support Vector Machines to forecast the maximal tourist arrival in a short time interval. And based on the data of tourists' arrive in JiuZhai valley in 2009, an experiment is made and the result shows that the hybrid

Table 3 The forecasting performances of LSSVM and the proposed model

				LLSVM		EMD&LLSVM	
LD	LP	Lags	FH	MAE	RMSE	MAE	RMSE
30	330	6	1	21.57	30.73	16.87	23.04
			2	21.89	34.40	16.30	22.12
			3	26.78	56.84	16.74	22.77
			4	22.79	30.84	15.84	21.40
			5	23.69	46.20	17.37	23.89

LT the length of training set, LP the length of the prediction set, *FH* forecasting horizon, *Lags* time lags

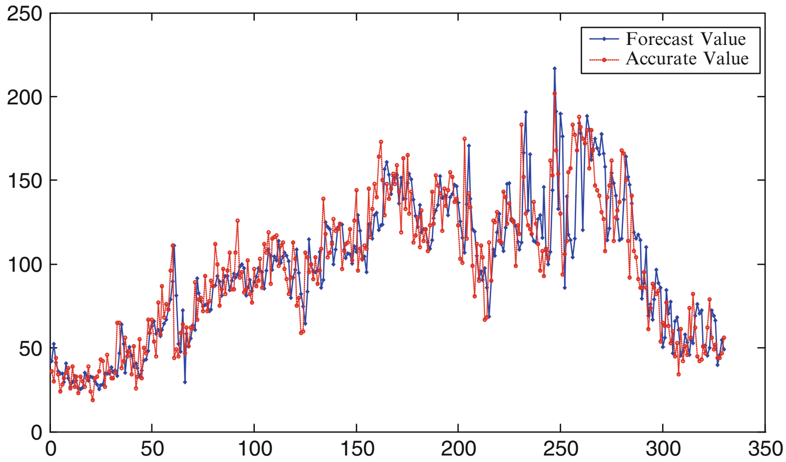

Fig. 4 The forecasting value and the accurate value of the 330 data

model is superior to LSSVM. Furthermore, Forecasting of tourists arrives in a short time interval is a very complex problem, which is influenced by many factors. How to identify the factors such as weather and season, etc., and considers them into the forecast model are the problems which will be researched in the future.

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A Method to Convert Integer Variables of Mixed Integer Programming Problems into Continuous Variables

Chung-Chien Hong and Yu-Hsin Huang

Abstract A mixed integer programming problem, is an optimization problem that includes both integer decision variables and continuous ones. Many engineering and management problems are mixed integer programming problems, most of which are NP-hard and take a long time to approach the optimal solution. Therefore, this paper proposes a method to convert the integer variables of a mixed integer programming problem into continuous variables. Then a mixed integer programming problem becomes an equivalent nonlinear programming problem or linear programming problem. And then, well developed nonlinear programming or linear programming solvers can be employed to efficiently and effectively search for the solution of a mixed integer programming problem. In addition to describing processes for converting integer variables into continuous ones, this paper provides two examples to demonstrate the conversion process and the benefits coming from the conversion methodology in the process of approaching the optimal solutions. Once the mixed integer programming is converted to an equivalent one where the decision variables are continuous, a nonlinear programming problem solver such as a differential evolutionary algorithm, can be used to solve the new equivalent problem. We show the procedure by solving a practical mixed integer programming problem that arises in a typical mechanical design problem. The result shows our solution is better than the ones from other four published mixed integer programming solvers.

Keywords Combinatorial optimization • Combinatorial analysis • Evolutionary computations • Global optimization

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1 Introduction

Mixed integer programming (MIP) problems are optimization problems with integer variables and continuous variables. Most MIP problems are NP hard which are very difficult to obtain their optimal solutions. Many real world problems, such as scheduling problems, vehicle routing problems, and network design problems, are MIP problems. However, only a few MIP problems have their own algorithms to approach the optimal solutions [1–3]. In addition, many researchers now use evolutionary algorithms to search the solutions of MIP problems. Evolutionary algorithms are based on the mechanism of natural selection, and randomly evolve a subset of feasible solutions to approximate optimal solutions. However, evolving randomly in the discrete feasible solution space of an MIP problem is still a difficult task. Therefore, evolving strategies in the feasible set of MIP problems are complicated and vary (e.g., the crossover processes of the genetic algorithm [4]). For both enriching the MIP solving techniques through including the well developed nonlinear programming (NLP) or linear programming (LP) solvers and overcoming the above aforesaid difficulty as in using evolutionary algorithms, a simple method to convert the integer variables into continuous ones becomes necessary.

Several recent studies [5–7] have tried to approach the optimal solutions of MIP problems through continuous feasible solution spaces. Lin et al. [6] and Ponsich and Coello [7] considered the original discrete feasible solution space of the MIP problem of interest as several separate continuous feasible solution subsets. They searched the best solution in each of those separate continuous subsets, and then chose the optimal solution of the MIP problem from these best solutions of the continuous subsets. Both these two studies found that searching the optimal solution in continuous spaces is more efficient and effective than in discrete ones. Therefore, it is natural to assume that performance would be enhanced if the searching processing works on a connected continuous space instead of several separate continuous spaces. Hong and Song [5] provided a simpler method than that of Boros and Hammer [8] to convert the binary variables (their values are restricted to 0 and 1) of an MIP problem into continuous variables with values ranging from 0 to 1. However, in [5] they only focus on MIP problems that have binary variables and no constraints.

This paper extends the results of Hong and Song [5] to the MIP problems with polynomial objective functions and constraints. According to the Stone-Weierstrass Theorem [9], a continuous function on a compact interval can be approximated by a polynomial. Thus, the proposed method in this paper can also handle MIP problems with continuous objective functions and constraints. Although several studies [10] in the field of polynomial optimization have provided some converting processes for MIP problems with polynomial objective functions and constraints, these processes are based on extensive knowledge of algebra and are only good for some special polynomials. In comparison to these existing converting processes, our proposed method in this paper is simpler, more easily implemented, and more general.

This paper first defines some terminology to describe the conversion methodology in Sect. 2. Section 3 describes each step of the conversion methodology.

Section 4 first provides two examples to demonstrate each step of the method while at the same time shows the possible advantages of the method. Then, in Sect. 4, the conversion methodology is followed by a differential evolutionary (DE) algorithm [11, 12], to solve the resulting NLP or LP problem. The procedure is shown by solving a typical mechanical design problem. The result shows that the performance of the combination of the conversion methodology and the DE algorithm is better than other four published MIP solvers. Finally, Sect. 5 provides a conclusion.

2 Terminology

This section defines some terminology to clearly describe the conversion methodology. Let $\mathbf{x}$ denote the vector $(x_1, x_2, \ldots, x_{n_1})$ where $x_i, i = 1, \ldots, n_1$ are integer variables. Let $\mathbf{y}$ denote the vector $(y_1, y_2, \ldots, y_{n_2})$ where $y_j, j = 1, \ldots, n_2$ are continuous variables. A polynomial, $P(\mathbf{x}, \mathbf{y})$ is a multi-linear polynomial (MLP) if the power of each integer variable $x_i, i = 1, \ldots, n_2$, in each term of $P(\mathbf{x}, \mathbf{y})$ is either 0 or 1. In this study, an MIP problem with both its objective function and constraints being continuous (polynomials/multi-linear polynomials) is called an MIP.C (MIP.P/MIP.MLP) problem. Moreover, if all the integer variables of an MIP.C (MIP.P/MIP.MLP) problem are binary variables, this MIP.C (MIP.P/MIP.MLP) problem is called a 01MIP.C (01MIP.P/01MIP.MLP) problem.

Let f, $g_i, i = 1, \ldots, m_1$, and $h_j, j = 1, \ldots, m_2$, be functions of $\mathbf{x}$ and $\mathbf{y}$. The following problem (MIP1) is a generalized mathematical formulation of MIP problems,

$$
\begin{aligned}
\textbf{(MIP1)} \qquad & \min_{\mathbf{x},\mathbf{y}} \ \mathbf{f}(\mathbf{x}, \mathbf{y}); \\
\textbf{subject to}: \ & g_h(\mathbf{x}, \mathbf{y}) \leq 0, \quad h = 1, \ldots, m_1; \\
& h_k(\mathbf{x}, \mathbf{y}) = 0, \quad k = 1, \ldots, m_2; \\
& 0 \leq x_i \leq a_i, \quad i = 1, \ldots, n_1; \\
& 0 \leq y_j \leq b_j, \quad j = 1, \ldots, n_2,
\end{aligned}
$$

where $x_i, i = 1, \ldots, n_1$ are integer variables of problem (MIP1) with lower bound 0 and upper bound a_i while $y_j, j = 1, \ldots, n_2$ are continuous variables with lower bound 0 and upper bound b_j. Adding real slack variables into the inequalities $g_i, i = 1, \ldots, m_1$, of problem (MIP1) converts these inequality constraints into equalities. Problem (MIP1) then becomes problem (MIP2) shown as below,

$$
\begin{aligned}
\textbf{(MIP2)} \qquad & \min_{\mathbf{x},\mathbf{y}} \ \mathbf{f}(\mathbf{x}, \mathbf{y}); \\
\textbf{subject to}: \ & h_k(x, y) = 0, \quad k = 1, \ldots, m; \\
& 0 \leq x_i \leq a_i, \quad i = 1, \ldots, n_1; \\
& 0 \leq y_j \leq b_j, \quad j = 1, \ldots, n_2.
\end{aligned}
$$

Problem (MIP2) serves as the mathematical formulation of MIP problems in the remainder of this paper. Note that if f and $h_k, k=1, \ldots, m$, in problem (MIP2) are continuous (polynomials/multi-linear polynomials), problem (MIP2) is an MIP.C (MIP.P/MIP.MLP) problem. Finally, we call an MIP problem an MIP problem without constraints if it only has constraints on the values of its decision variables.

3 The Conversion Methodology

This section introduces the method to convert the integer variables of an MIP.P problem into continuous variables. Then the original MIP.P problem becomes an equivalent NLP problem. The conversion method includes the following four steps,

- Step1. Convert an MIP.P problem into an equivalent 01MIP.P problem.
- Step2. Convert a 01MIP.P problem into an equivalent 01MIP.MLP problem.
- Step3. Convert a 01MIP.MLP problem into a 01MIP.MLP problem without constraints.
- Step4. Convert a 01MIP.MLP problem without constraints into an equivalent NLP/LP problem.

Let function f and $h_k, k=1, \ldots, m$ in problem (MIP2) be polynomials and then treat problem (MIP2) as the MIP.P problem of interest. The following discussion describes these four steps to convert problem (MIP2) into an equivalent NLP or LP problem.

Step1. Convert an MIP.P problem into an equivalent 01MIP.P problem.

Let problem (MIP2) be the MIP.P problem of interest. We replace each integer variable $x_i, i=1, \ldots, n_1$ of problem (MIP2) by,

$$x_i = 2^0 x_{i_0} + 2^1 x_{i_1} + 2^2 x_{i_2} + \cdots + 2^p x_{i_p}, \tag{1}$$

where $x_{i_l}, l = 1, \ldots, p$, are binary variables and $p = \min\{(r-1)|2^r - 1 \geq a_i\}$. However, if $a_i < 2^{p+1} - 1$, the value of $2^0 x_{i_0} + 2^1 x_{i_1} + 2^2 x_{i_2} + \cdots + 2^p x_{i_p}$ may exceed a_i, the upper bound of x_i. This condition requires an additional inequality constraint, $2^0 x_{i_0} + 2^1 x_{i_1} + 2^2 x_{i_2} + \cdots + 2^p x_{i_p} - a_i \leq 0$, in problem (MIP2) to restrict the value of $2^0 x_{i_0} + 2^1 x_{i_1} + 2^2 x_{i_2} + \cdots + 2^p x_{i_p}$ to interval $[0, a_i]$. This inequality constraint can be rewritten as an equality constraint by adding a slack variable, s_i. The equality constraint and the boundaries of this slack variable are

$$2^0 x_{i_0} + 2^1 x_{i_1} + 2^2 x_{i_2} + \cdots + 2^p x_{i_p} - a_i + s_i = 0, \tag{2}$$

and

$$0 \leq s_i \leq a_i. \tag{3}$$

Problem (MIP2) is changed from an MIP.P problem to a 01MIP.P problem after replacing each integer variable $x_i, i = 1, \ldots, n_1$, with its corresponding combination of binary variables as in (1) and putting constraints (2) and (3) for each $x_i, i = 1, \ldots, n_1$, into problem (MIP2).

Let the number of binary variables of the 01MIP.P problem be $\widehat{n}_1$. Then, use $\widehat{x}_i, i = 1, \ldots, \widehat{n}_1$ to denote these binary variables and put $\widehat{\mathbf{x}} = \left(\widehat{x}_1, \widehat{x}_2, \ldots, \widehat{x}_{\widehat{n}_1}\right)$. Let the number of continuous variables of the 01MIP.P problem be $\widehat{n}_2$. Use $\widehat{y}_j, j = 1, \ldots, \widehat{n}_2$ to denote these continuous variables and $\widehat{\mathbf{y}} = \left(\widehat{y}_1, \widehat{y}_2, \ldots, \widehat{y}_{\widehat{n}_2}\right)$. Denote the upper bound of $\widehat{y}_j$ by $\widehat{b}_j$. Let $\widehat{f}$ be the objective function of the 01MIP.P problem and let $\widehat{h}_k, k = 1, \ldots, \widehat{m}$, be the constraints. This step uses the processes above to convert problem (MIP2) into an equivalent 01MIP.P problem, problem (01MIP.P), shown as below:

$$\begin{aligned} &(\mathbf{01MIP.P}) \quad \min_{\widehat{\mathbf{x}},\widehat{\mathbf{y}}} \ \widehat{\mathbf{f}}\left(\widehat{\mathbf{x}}, \widehat{\mathbf{y}}\right); \\ &\mathbf{subject\ to}: \widehat{h}_k\left(\widehat{\mathbf{x}}, \widehat{\mathbf{y}}\right) = 0, \ k = 1, \ldots, \widehat{m}; \\ &\qquad \widehat{x}_i\left(1 - \widehat{x}_i\right) = 0, \ i = 1, \ldots, \widehat{n}_1; \\ &\qquad 0 \le \widehat{y}_j \le \widehat{b}_j, \ j = 1, \ldots, \widehat{n}_2. \end{aligned}$$

Step2. Convert a 01MIP.P problem into an equivalent 01MIP.MLP problem.

This step requires the following lemma.

Lemma 3.1. *Let x be a binary variable. Then, $x^r = x$ for any non-zero value r.*

According to Lemma 3.1, a binary variable with any non-zero power in a polynomial function can be replaced by the variable itself. The power of each integer variable in each term of the objective function or the constraints of problem (01MIP.P) can be reduced to 1 from a positive number because all its integer variables are binary variables. Thus, problem (01MIP.P) can be rewritten as a 01MIP.MLP problem. After reducing the powers of binary variables, $\widehat{x}_i, i = 1, \ldots, \widehat{n}_1$ in the objective function and the constraints of problem (01MIP.P) to 1 from positive numbers, $\widehat{f}$ and $\tilde{h}_k, k = 1, \ldots, \widehat{m}$ become MLPs $\tilde{f}$ and $\tilde{h}_k, k = 1, \ldots, \widehat{m}$, respectively. Thus, this step converts problem (01MIP.P) into an equivalent 01MIP.MLP problem, problem (01MIP.MLP), shown as below:

$$\begin{aligned} &(\mathbf{01MIP.MLP}) \quad \min_{\widehat{\mathbf{x}},\widehat{\mathbf{y}}} \ \tilde{\mathbf{f}}\left(\widehat{\mathbf{x}}, \widehat{\mathbf{y}}\right); \\ &\mathbf{subject\ to}: \tilde{h}_k\left(\widehat{\mathbf{x}}, \widehat{\mathbf{y}}\right) = 0, \ k = 1, \ldots, \widehat{m}; \\ &\qquad \widehat{x}_i\left(1 - \widehat{x}_i\right) = 0, \ i = 1, \ldots, \widehat{n}_1; \\ &\qquad 0 \le \widehat{y}_j \le \widehat{b}_j, \ j = 1, \ldots, \widehat{n}_2. \end{aligned}$$

Step3. Convert a 01MIP.MLP problem into an equivalent 01MIP.MLP problem without constraints.

Using the Lagrange multiplier method, a constraint can be ignored by adding proper penalty values to the objective function for possible solutions that violate this constraint. In this case, assign large positive values to multipliers $\lambda_k, k = 1, \ldots, \widehat{m}$, and add $\sum_{k=1}^{\widehat{m}} \lambda_k \tilde{h}_k^2 \left(\widehat{\mathbf{x}},\ \widehat{\mathbf{y}}\right)$ to the objective function to remove these equality constraints of problem (01MIP.MLP). Then, the objective function of problem (01MIP.MLP) becomes

$$\tilde{f}\left(\widehat{\mathbf{x}}, \widehat{\mathbf{y}}\right) + \sum_{k=1}^{\widehat{m}} \lambda_k \tilde{h}_k^2 \left(\widehat{\mathbf{x}}, \widehat{\mathbf{y}}\right). \tag{4}$$

Since each integer variable in (4) is a binary variable, (4) can be rewritten as an MLP by following the same process in Step 2. Let $\boldsymbol{\theta}\left(\widehat{\mathbf{x}}, \widehat{\mathbf{y}}\right)$ denote the MLP from (4). Thus, this step converts problem (01MIP.MLP) into an equivalent 01MIP.MLP problem without constraints, problem (01MIP.MLP-NC), shown as below:

$$\begin{aligned} &(\mathbf{01MIP.MLP\text{-}NC}) \qquad \min_{\widehat{\mathbf{x}}, \widehat{\mathbf{y}}} \quad \boldsymbol{\theta}\left(\widehat{\mathbf{x}}, \widehat{\mathbf{y}}\right); \\ &\qquad\qquad \textbf{subject to}: \widehat{x}_i\left(1 - \widehat{x}_i\right) = 0, \quad i = 1, \ldots, \widehat{n}_1; \\ &\qquad\qquad\qquad\qquad 0 \le \widehat{y}_j \le \widehat{b}_j, \quad j = 1, \ldots, \widehat{n}_2. \end{aligned}$$

Step4. Convert a 01MIP.MLP problem without constraints into an equivalent NLP/LP problem.

This step requires the following lemma.

Lemma 3.2. *Let problem (NLP) be a relaxed problem of problem (01MIP.MLP-NC). Thus, problem (NLP) is an NLP problem and its mathematical formulation is written as*

$$\begin{aligned} &(\mathbf{NLP}) \qquad \min_{\widehat{\mathbf{x}}, \widehat{\mathbf{y}}} \quad \boldsymbol{\theta}\left(\widehat{\mathbf{x}}, \widehat{\mathbf{y}}\right); \\ &\textbf{subject to}: 0 \le \widehat{x}_i \le 1, \qquad i = 1, \ldots, \widehat{n}_1; \\ &\qquad\qquad\quad 0 \le \widehat{y}_j \le \widehat{b}_j, \qquad j = 1, \ldots, \widehat{n}_2, \end{aligned}$$

Then, there exits an optimal solution of problem (NLP) whose values for variables $\widehat{x}_i, i = 1, \ldots, \widehat{n}_1$, are either 0 or 1.

Proof. At first, assume that there exists no optimal solution of problem (NLP) whose values for variables $\widehat{x}_i, i = 1, \ldots, \widehat{n}_1$, are either 0 or 1. Let $\left(\widehat{\mathbf{x}}^*,\ \widehat{\mathbf{y}}^*\right) = \left(\widehat{x}_1^*, \widehat{x}_2^*, \ldots, \widehat{x}_{n_1}^*, \widehat{y}_1^*, \widehat{y}_2^*, \ldots, \widehat{y}_{\widehat{n}_2}^*\right)$ be an optimal solution of problem (NLP). Then, there is at least one variable of $\widehat{x}_i, i = 1, \ldots, \widehat{n}_1$, whose optimal value is either 0 or 1. Denote this variable by $\widehat{x}_t$. Because function $\boldsymbol{\theta}\left(\widehat{\mathbf{x}}, \widehat{\mathbf{y}}\right)$ is an MLP, the optimal value, $\boldsymbol{\theta}\left(\widehat{\mathbf{x}}^*, \widehat{\mathbf{y}}^*\right)$, can be expressed as

$$\begin{aligned} &\widehat{x}_t^* \theta_1\left(\widehat{x}_1^*, \ldots, \widehat{x}_{t-1}^*, \widehat{x}_{t+1}^*, \ldots, \widehat{x}_{\widehat{n}_1}^*, \widehat{\mathbf{y}}^*\right) \\ &\quad + \theta_2\left(\widehat{x}_1^*, \ldots, \widehat{x}_{t-1}^*, \widehat{x}_{t+1}^*, \ldots, \widehat{x}_{\widehat{n}_1}^*, \widehat{\mathbf{y}}^*\right), \end{aligned} \tag{5}$$

where both θ_1 and θ_2 are functions of all the variables of problem (NLP) except variable $\widehat{x}_t$.

If $\theta_1\left(\widehat{x}_1^*,\ldots,\widehat{x}_{t-1}^*,\widehat{x}_{t+1}^*,\ldots,\widehat{x}_{\widehat{n}_1}^*,\widehat{\mathbf{y}}^*\right)$ is larger than zero, it is necessary to adjust the value of $\widehat{x}_t$ from $\widehat{x}_t^*$ to 0 to obtain a smaller value than $\boldsymbol{\theta}\left(\widehat{\mathbf{x}}^*,\widehat{\mathbf{y}}^*\right)$ for problem (NLP). Otherwise, adjust the value of $\widehat{x}_t$ from $\widehat{x}_t^*$ to 1 to obtain a value equal to or smaller than $\boldsymbol{\theta}\left(\widehat{\mathbf{x}}^*,\widehat{\mathbf{y}}^*\right)$. This contradicts the assumption above.

From Lemma 3.2, problem (NLP) has an optimal solution whose values for these variables, $\widehat{x}_i, i = 1,\ldots,\widehat{n}_1$, are either 0 or 1. Then, we can obtain the optimal solution of problem (01MIP.MLP-NC) through solving problem (NLP). Thus, in this step, we can relax problem (01MIP.MLP-NC) into an equivalent NLP problem, problem (NLP).

According to the above four steps, we know the solution of problem (01MIP.MLP-NC) can be obtained through solving problem (NLP). Then, the solution of original problem (MIP.P) can be obtained by putting the optimal solution of problem (01MIP.MLP-NC) in to (1).

4 Implementation

In this section we demonstrate the conversion method and show the possible advantages of using this conversion method. Each of Sects. 4.1 and 4.2 gives an MIP.P problem and then show how we convert it into an NLP problem through step 1 to step 4 in Sect. 3. In Sect. 4.3 we combine the conversion method with the DE algorithm to solve a practical mechanical design problem and then compare the results with those coming from other four published MIP problem solvers [6, 14–16].

4.1 The First Example

The following is an MIP.P problem and we are going to use it to show the four steps of the conversion methodology.

$$\begin{aligned} \text{min.}\ & f(\mathbf{x},\mathbf{y}) = x - xy^3 + y^2; \\ \text{subject to}:\ & (i)\quad x + y^2 \le 3; \\ & (ii)\quad x \in \{0,1,2\}; \\ & (iii)\quad y \in \{0,1\}. \end{aligned}$$

In step 1, integer variable x in the above MIP.P problem is expressed by two binary variables, x_{11} and x_{12}. Since the maximum value of x, 2, is less than 2^2-1, inequality constraint $x_{11}+2x_{12}\le 2$ is added into the problem. After using slack variables, s_1

and s_2, and reducing these powers of binary variables to 1 in step 2, we obtain the following 01MIP.MLP problem,

$$
\begin{aligned}
\min.\ & f(\mathbf{x},\mathbf{y}) = (x_{11}+2x_{12}) - (x_{11}+2x_{12})\,y + y;\\
\text{subject to}: & (i) \quad x_{11}+2x_{12}+y+s_1-3=0;\\
& (ii) \quad x_{11}+2x_{12}-2+s_2=0;\\
& (iii) \quad x_{11}, x_{12}, y \in \{0,1\};\\
& (iv) \quad 0 \le s_1 \le 3;\\
& (v) \quad 0 \le s_2 \le 2.
\end{aligned}
$$

Then, using the Lagrange multiplier method in Step 3 and transforming the binary variables into the continuous variables with values between 0 and 1 in step 4, the above 01MIP.MLP problem becomes an equivalent NLP problem shown below,

$$
\begin{aligned}
\min.\ \quad & f(\mathbf{x},\mathbf{y}) = x_{11}+2x_{12}-x_{11}y-2x_{12}y+y\\
& \quad + \lambda\big(-8x_{11}-12x_{12}-5y+s_1^2+s_2^2\\
& \quad + 8x_{11}x_{12}+2x_{11}y+2x_{11}s_1\\
& \quad + 4x_{12}y+4x_{12}s_1+2ys_1-6s_1\\
& \quad + 2x_{11}s_2+4x_{11}s_2-4s_2\big);\\
\text{subject to}: & (i) \quad 0 \le x_{11}, x_{12}, y \le 1;\\
& (ii) \quad 0 \le s_1 \le 3;\\
& (iii) \quad 0 \le s_2 \le 2.
\end{aligned}
$$

4.2 The Second Example

The following is an MIP.P problem with only constraints for the possible values of control variables and we are going to use it not only to show the conversion method but also to demonstrate the possible advantage of using this method,

$$
\begin{aligned}
\min.\ \quad & x_1^5 - x_1x_2 + x_1^2x_2 + x_1x_3 - x_1x_2^2x_3 + x_1y_1 - x_1^3y_1 - y_1;\\
\text{subject to}: & (i) \quad x_1 \in \{0,1\};\\
& (ii) \quad x_2 \in \{0,1\};\\
& (iii) \quad x_3 \in \{0,1,2,3,4,5,6,7\};\\
& (iv) \quad 0 \le y_1 \le 1.
\end{aligned}
$$

x_3 in the above MIP.P problem is expressed by three binary variables, x_{31}, x_{32}, x_{33}. Since x_1 and x_2 are binary variables, all the powers of these two variables in the objective function can be replaced by 1 in step 2. Therefore, the problem becomes a 01MIP.MLP problem shown below,

$$
\min.\quad x_1 + x_1(x_{31}+2x_{32}+4x_{33}) - x_1x_2(x_{31}+2x_{32}+4x_{33}) - y_1,
$$

where x_1, x_2, x_{31}, x_{32} and x_{33} are binary variables and y_1 is a continuous variable between 0 and 1. In addition, as the coefficients of the terms with x_2 in the objective function of the 01MIP.MLP problem are all negative, the optimal value of x_2 must be 1 for minimizing the value of objective function. After we assign the optimal value 1 to x_2, the objective function of this problem becomes,

$$x_1 + x_1 (x_{31} + 2x_{32} + 4x_{33}) - x_1 (x_{31} + 2x_{32} + 4x_{33}) - y_1 = x_1 - y_1.$$

Since there are only constraints for possible values of control variables in this problem, we jump to step 4 directly. These binary variables become continuous variables with values between 0 and 1 and the problem becomes a simple LP problem shown as below,

$$\begin{aligned} \text{min}.\ & x_1 - y_1; \\ \text{subject to}: & 0 \le x_1 \le 1; \\ & 0 \le y_1 \le 1. \end{aligned}$$

From the above LP problem, we know the optimal solutions for x_1, x_2 and y_1 in the original MIP problem are 0, 1 and 1, respectively, and the optimal solution for x_3 can be any integer number from 0 to 7.

4.3 *The Mechanical Design Problem*

This subsection combines the proposed conversion methodology and the DE algorithm [11, 12] to solve the typical mechanical problem introduced by Sandgren [13]. The DE algorithm is an evolutionary algorithm with an evolving strategy in continuous feasible spaces. This mechanical problem is a design problem that seeks to optimize the design of four dimensions of a pressure vessel to minimize the total cost of materials, forming, and welding.

The four dimensions of a pressure vessel are represented by variables, x_1, x_2, y_1, y_2. The variables x_1 and x_2 are integer variables and $\mathbf{x} = (x_1, x_2)$, y_1 and y_2 are continuous variables and $\mathbf{y} = (y_1, y_2)$. Let $g_i(\mathbf{x},\mathbf{y}), i = 1, \ldots, 4$ be four inequality constraints to restrict the design of the pressure vessel. Let $f(\mathbf{x},\mathbf{y})$ be the total cost of materials, forming, and welding. The mathematical formulation of this mechanical design problem is shown as below:

$$\begin{aligned} \min_{\mathbf{x},\mathbf{y}}\ \mathbf{f}(\mathbf{x},\mathbf{y}) &= 0.6224\,(0.0625x_1)\,y_1 y_2 + 1.7781\,(0.0625x_2)\,y_1^2 \\ &\quad + 3.1661(0.0625x_1)^2 y_2 + 19.84\,(0.0625x_1)^2 y_1; \\ \textbf{subject to}: (i)\quad & g_1(\mathbf{x},\mathbf{y}) = 0.0193y_1 - 0.0625x_1 \le 0; \\ (ii)\quad & g_2(\mathbf{x},\mathbf{y}) = 0.00954y_1 - 0.0625x_2 \le 0; \\ (iii)\quad & g_3(\mathbf{x},\mathbf{y}) = 750 \times 1,728 - \pi y_1^2 y_2 - \tfrac{4}{3}\pi y_1^3 \le 0; \\ (iv)\quad & g_4(\mathbf{x},\mathbf{y}) = y_2 - 240 \le 0. \end{aligned}$$

Table 1 The solutions for the mechanical design problem from five algorithms, IDCNLP, SA, MVEP, MIHDE-AMM and our conversion method with the DE algorithm

Methods	IDCNLP	SA	MVEP	MIHDE-AMM	Our converting method + DE
x_1	18	18	16	15	12
x_2	10	10	10	8	6
x_3	48.3807	58.2900	51.1958	48.5765	37.70197
x_4	111.7449	43.6930	90.7821	110.0559	240
g_1	−0.1913	−0.0250	−0.0119	0.0000	−0.0224
g_2	−0.1643	−0.0689	−0.1366	−0.0366	−0.01532
g_3	−75.8750	−6.5496	−13, 584.5631	0.0000	−207.6480
g_4	−128.2551	−196.3070	−149.2179	−129.9441	0.0000
$f(x, y)$	8, 048.6190	7, 197.7	7, 108.6160	6, 370.7035	6, 019.771

Table 1 shows the results for this mechanical design problem produced by the proposed conversion method with the DE algorithm and four other published MIP solvers, IDCNLP [14], SA [15], MVEP [16] and MIHDE-AMM [6]. According to Table 1, the proposed conversion method with the DE algorithm provides a better solution than the other four algorithms.

5 Conclusion and Further Work

This paper proposes a simple and easily implemented method to convert an MIP.P problem into an equivalent NLP or LP problem. Then, the well-developed and readily available NLP or LP solvers are used to efficiently and effectively search for the optimal solutions of MIP.P problems. According to the Stone-Weierstrass theorem [2], a continuous function on a compact interval can be approximated by a polynomial. Thus, the proposed method also can handle MIP.C problems. In Sect. 4.2, we have observed that the proposed conversion method possibly transforms an MIP.P problem into a simple NLP or LP problem. Through the simplification process, the performance of solving an MIP.P problem would be improved significantly. In Sect. 4.3, the implementation to the real world mechanical design problem has demonstrated that the searching process in the continuous feasible solution space of an equivalent NLP problem can go closer to the optimal solution than that in the discrete feasible one of the original MIP problem.

From the results of Sects. 4.2 and 4.3, this proposed conversion method can possibly be applied to speed up the searching process and improve the search quality as an interesting MIP problem is too complicated to be solved directly. The method we have presented is designed to convert the original MIP problem into an NLP or LP problem with simple objective function and constraints. Then, the optimal solution of the MIP problem can be approached through interior points in a continuous space instead of a large number of discrete feasible spaces. It is worth mentioning that searching in a continuous space often provides a better solution than searching in the original discrete spaces. Therefore, the proposed conversion method will also be useful for solving a multi-objective programming problem with integer variables. We can expect the pareto front coming out from a continuous feasible space would be better than the one from discrete spaces.

Finally, we would like to mention that the searching performance also depends on the chosen algorithm for solving the NLP or LP problem. Therefore, our next study will focus on how we choose an efficient and effective algorithm for each type of LNP or LP problem that results from the conversion methodology.

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Simulation-Based Evolution Algorithm for Automated Material Handling System in a Semiconductor Fabrication Plant

James T. Lin and Chao-Jung Huang

Abstract The automated material handling system (AMHS) in semiconductor industry plays a vital role in reducing wafer cycle times and enhancing fabrication plant productivity. Vehicle allocation for the AMHS is a challenging task because of the complexity of the manufacturing process and the stochasticity introduced by the inherent variability of processing times. This situation is observed especially in 300 mm wafer fabrication plants where the AMHS comprises both interbay and intrabay systems that perform the timely deliveries. To address this issue, we use the optimal computing budget allocation (OCBA) and extend it by adding genetic algorithm (GA). Under this combined approached, the number of iterations of each alternative is determined by OCBA, and then the optimal solution in the domain of feasible solutions is found through GA. This research provides a useful reference for both scholars and practitioners seeking optimal allocation of lithographical resources and number of iterations using random parameters.

Keywords AMHS • GA • OCBA

1 Introduction

As the cost and complexity in semiconductor fabrication facilities increase, companies are driven to improve productivity while reducing costs and cycle times. Automated material handling system (AMHS) is an effective contributor to reducing wafer cycle times and improving on-time delivery in 300 mm fabrication facilities (fabs). AMHS is composed of interbay and intrabay systems that collaborate with each other to deliver wafer lots to the proper place at the specified time. The interbay

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system can transfer wafer lots between process bays, whereas the intrabay system can transfer wafer lots within the same process bay. In 300 mm wafer fabs, when merge/diverge links are used, wafer lots can be moved among production tools located at different bays to reduce the excessive use of the interbay system [1].

Vehicle allocation for the AMHS in 300 mm fabs is a challenging task. Reasons include the complexity of the AMHS design, the high variability of processing time, the uncertainty of wafer start for each day and work in process (WIP) left from the previous day, as well as the high throughput requirement. Simultaneous consideration for both the intrabay and interbay systems imposes added challenges to vehicle allocation attributed to the large decision space and the unknown interaction between the two systems. Previous research has investigated the configuration of AMHS that can avoid vehicle collision, deadlock, or blockage, as well as prevent paralysis of the handling system [2, 3]. Dispatching rules for vehicles have also been examined to improve system performance. Lin, Wang, and Yen (2001) [4] further took into consideration distinct track selections and search mechanisms. Mackulak and Savory used simulation combined with the technique of design of experiment to compare the performance of two layouts of the intrabay system. Lin et al. (2003) [5], Lin et al. (2004) [6] proposed a new concept for 300 mm AMHS, called "connecting transport AMHS," to improve the task of moving wafers between and within bays by a single system using interconnected lines.

In the existing literature, AMHS performance is estimated either by an analytical or a simulation model. The former is either a deterministic optimization model or a queuing model in which oversimplified assumptions are usually taken, such as assuming the response time is independent of the move's original location, and hence may not be applicable to real-world problems. Meanwhile, simulation is considered a powerful tool in analyzing the performance of a manufacturing system. An advantage of simulation is that it can account for all important details in the manufacturing process. However, the existing simulation-based research for AMHS has two problems. First, most simulation models are based on a "from–to" table, absent consideration for the routings of different products, the stochasticity of processing time, the uncertainty of WIP carried over from the past day, and wafer start for each day. The models thus cannot accurately characterize the actual system, leading to underestimation or overestimation of system performance. Second, simulation is time-consuming, especially when the decision space is large.

This research attempts to address these two problems. Specifically, we develop a simulation model in light of the real system rather than the "from–to" table. The simulation model can better represent the system and yields better prediction for the system behavior of interest. Further, we propose to use a simulation optimization technique to address the vehicle allocation problem. Simulation optimization has been an emerging field over the past decade. It refers to optimization of a stochastic system where performance can only be evaluated by stochastic simulation. The optimum of the simulation model is located via a systematic and efficient scheme, leading to reduced computing time. Many advances have been made on the methodological development, and many successful practical applications have been found. By utilizing simulation optimization, domain users can dynamically adjust the number of vehicles daily instead of relying on domain knowledge, which is biased and leads to suboptimal vehicle allocation.

This research is focused on vehicle allocations of AMHS in a typical 300 mm wafer fab composed of several intrabay systems and one interbay system. A discrete-event simulation model is developed in Plant Sim (eM-Plant) as a representative system for the AMHS in a typical 300 mm wafer fab. A simulation optimization technique is then designed to explore the decision space and search for the optimum of the simulation model. The decision variable indicates the number of vehicles with respect to each intrabay and interbay, and the objective function is intended to maximize the expected total transports delivered by the entire AMHS. As WIP and wafer start vary daily, so does the vehicle allocation in order to fulfill the required amount of transport. A naïve approach, such as surveying all solutions (system configurations) comprehensively and selecting the best one based on comparison, is not possible because of its excessive computing time. For instance, the AMHS contains ten intrabay systems and one interbay system, with the number of vehicles for each system ranging from 0 to 10. The total number of possible system configurations is 10*e11, which fails the approach discussed above. As such, the proposed scheme is more appropriate.

2 System Descriptions

In this research, a representative layout of AMHS contains a single loop of an interbay system, 10 intrabay systems, and 20 stockers, as shown in Fig. 1.

To represent the actual system faithfully, empirical data are collected and analyzed for the simulation model. For example, the lot coded by AK01-A enters the process tool in the diffusion bay at 23:07:44 on 2010/09/02 and finishes the process, leaving at 23:10:21 on the same day. The same lot then goes to and arrives at the process tool in the thin-film bat at 23:45:47.

Our simulation model is developed in Plant Sim (eM-Plant), which is object-oriented with characteristics of hierarchy, inheritance, and concurrent simulation. The basic objects are provided for use and can be easily modified according to users' requirements. User-defined objects can be created and further combined to form a new object, such as a loop that consists of three objects: buffer, track, and transporter. The settings of the simulation are described as follows:

1. Vehicles velocity: 1 m/s.
2. Stocker's crane cycle times are normally distributed with a mean of 18 s and a standard deviation of 5 s.
3. Time for loading/unloading of wafer lots: 20 s.
4. Each tool has four load ports.
5. Dispatching rule of the interbay system is a combination of the shortest distance with the nearest vehicle (SD_NV) and the first-encounter-first-served rule [4].

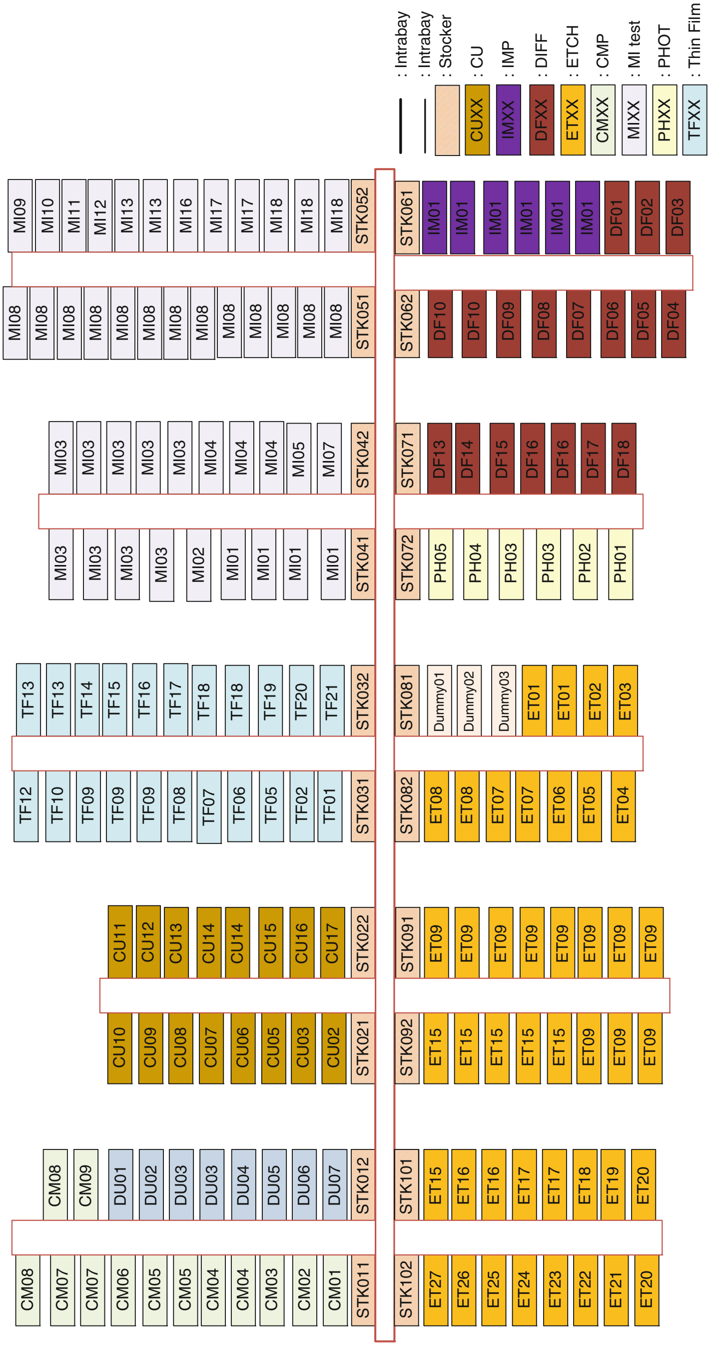

Fig. 1 A representative AMHS in typical 300 mm fabs

Table 1 Input parameters for the simulation model

Station Family	Station	Minimum batch	Maximum batch
StnFam_DF07	DF07_01	1	5
StnFam_DF08	DF08_01	1	5
StnFam_DF09	DF09_01	1	5
StnFam_DF10	DF10_01	1	4
StnFam_DF10	DF10_02	1	4

Table 2 Routing data

Route	Step	Station family	Process time (min)	Unit
Route_A	1980.192	StnFam_MI04	5	per_lot
Route_A	1980.21	StnFam_MI09	9.6	per_lot
Route_A	1980.225	StnFam_MI08	12.8	per_lot
Route_A	1980.24	StnFam_DF03	47.4	per_batch
Route_A	1980.26	StnFam_MI03	4	per_lot
Route_A	1980.28	StnFam_MI04	5	per_lot
Route_A	2080.02	StnFam_PH04	0.75	per_piece
Route_A	2080.04	StnFam_MI13	8	per_lot
Route_A	2080.05	StnFam_MI08	12.8	per_lot
Route_A	2080.06	StnFam_MI01	14.4	per_lot

In the developed simulation model, all wafer lots are moved in clockwise direction regardless of the interbay or intrabay systems. When the wafer lot on a production tool is done, the transport request is sent, and the vehicle with the shortest distance will be called to complete the transport request. If none of the vehicles are available, the transport request will be put on a waiting list, and the transport request with the shortest distance will be prioritized once a vehicle is available. As the amount and frequency of transport requests depend on the dispatching rule, routing of products, stochastic processing time, and the wafer start, no analytical formula can describe their relationship given its complexity. The only feasible approach is to rely on the fast-running simulation.

A part of the simulation input data, such as the different types of machines, processing batch size, load port numbers, internal buffer size, machine numbers, and lot processing time, is provided in Table 1.

Moreover, partial routing of products and the associated process time is given in Table 2.

3 Solution Methodology

Production process management in the real world is extremely complex, characterized by non-linear or uncertain relationships for which optimal solutions are difficult to find via mathematical approaches. Hence, simulation remains the best

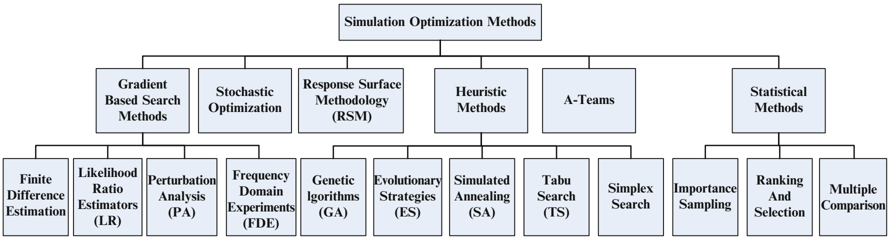

Fig. 2 Six categories of simulation optimization approaches [7]

tool for analyzing complex systems and evaluating their performance. The optimal solution may be identified through obtaining solutions for all cases, which wastes resources and time. As researchers look for the best solution, individual simulation is considered inefficient. Accordingly, many scholars have studied simulation optimization. Carson (1996) [7] categorized approaches to simulation optimization as shown in Fig. 2.

Many traditional ranking and selection approaches have been put forth, including those of Rinott (1978) [8], Dudewicz and Dalal (1975) [9], and Matejcik and Nelson (1993) [10]. Chen et al. (2000) proposed optimal computing budget allocation (OCBA), focused on single-objective performance, which effectively allocated simulation iterations available for required alternative estimations. Chen et al. (2000) compared OCBA with conventional equal allocations or PTV approaches and found that OCBA obtains optimal design alternative at a lower cost [11].

Genetic algorithm (GA) was first proposed by Holland (1975), based on Darwinian notions of natural selection and survival of the fittest [12]. It mimics biological processes in its evolutionary algorithms. The mother chromosome in each generation undergoes evolution. Through competition, selection, replication, crossover, and mutation, better daughter chromosomes are retained whereas those less fit are eliminated. The evolutionary algorithm process has an unfortunate tendency to converge on local optima, which may impair its capability to find the global optimal solution. Consequently, as the foregoing review makes clear, GA has already become a useful tool for obtaining solutions to optimization problems. This research adopts GA to obtain the AMHS simulation optimization problem.

3.1 Integrating OCBA into GA

OCBA begins by conducting an initial simulation on each alternative. It then takes the results of the simulation performance and variance in the outcomes as bases for allocating simulation times. In the previous passage, the simulation analysis of the design alternatives has been conducted using OCBA. As the alternatives

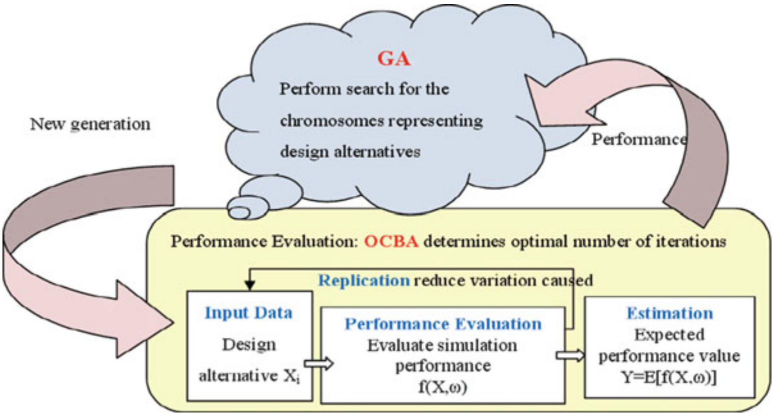

Fig. 3 Flowchart of GA and OCBA process

are few and limited, the initial simulation may be processed one by one. Chen and Lee recommended that for effective brute force problem solving, the number of alternatives should fall between 5 and 200. If the number of alternatives of the problem to be solved exceeds 200, the initial simulation of all alternatives may be too costly. Therefore, this section presents an algorithm that combines GA with OCBA focused on the large-scale random problem. In the method used in this research, OCBA is a search tool that assists GA. GA conducts searches for alternatives in a greater space, whereas OCBA conducts effective resource allocation for the simulation of the alternatives found, which makes the evaluation of performance of alternatives more reliable. Figure 3 shows the relationship between GA and OCBA. OCBA primarily determines the optimal number of iterations of the simulation after evaluation of the performance of multiple alternatives, and then classifies the optimal design alternative based on performance. However, a great number of alternatives cannot be performed one by one by the simulation. The GA algorithm is then used to search for alternatives.

3.2 GA Combined with OCBA Process

The pseudo code of GA with OCBA proposed in this research is as follows: t denotes the number of generations; P(t) denotes a given generation's parent solution; Q(t) denotes a given generation's daughter solution; and M(t) denotes a given generation's mating pool. Pseudo code represents the GA's process (Table 3) in which each procedure represents several large steps.

This research combines GA and OCBA as shown in Fig. 4.

Table 3 GA With OCBA pseudo code

Algorithm: GA with OCBA pseudo code

```
Begin
    t = 1
    Initialization: generate random population P(t);
    Evaluation: evaluate fitness value of P(t) by MOCBA;
      Elite population: find the Pareto set Pf(t) and record;
    While (not termination condition) do
      Selection: create M(t) from P(t) by binary tournament selection;
        Crossover: create Q(t) from M(t) by uniform crossover;
        Mutation: create Q(t) from M(t) by one point mutation;
        Evaluation: evaluate fitness of Q(t) by simulation;
          Create R(t) by combining P(t), Pf(t) and Q(t);
      Replacement: select P(t+1) from R(t);
    t = t +1
  end;
end;
```

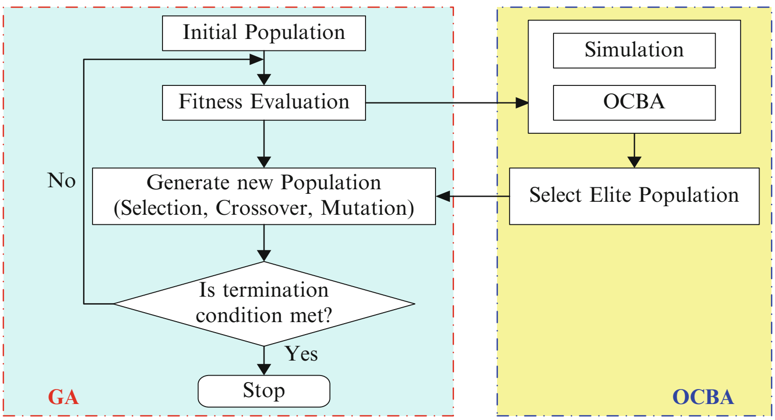

Fig. 4 Flowchart of the GA with OCBA process

The GA-OCBA process has seven steps.

Step 1: Parameter Setting

1. GA: Initial population, capacity of crossover pool, number of new parent generations through crossover or mutation, probability of crossover and mutation, largest number of iterations.
2. OCBA: Initial simulation n_0, additionable simulation iterations Δ in each iteration.

Step 2: GA produces the initial population randomly according to the pre-determined initial population size.

Step 3: OCBA determines the optimal number of simulation iterations of each design alternative and conducts the simulated performance analysis. When the termination criterion of OCBA is satisfied.

Step 4: If the termination criterion of GA is satisfied, the process skips to Step 6; if not, Step 5 is performed.

Step 5: A new parent generation is created.

1. Crossover: uniform crossover
2. Mutation: single point mutation

Step 6: The next generation is created.

1. Pareto set
2. Selection: a portion of chromosomes in the crossover pool is subjected to bilateral tournament competition
3. New filial generation

Step 7: Export the Pareto set recorded in the Elite population list.

4 Empirical Study

In this section, we conduct an empirical study based on actual data obtained from a wafer fab in a leading semiconductor company in Taiwan. As described in Sect. 2, a typical AMHS system with ten intrabays and one interbays in a 300 mm wafer fab is developed in Plant Sim (eM-Plant) as an abstraction of the actual system in Fig. 1. The simulation model closely follows the logic implemented in the real system. Vehicle allocations for ten intrabays and one interbay are set as decision variables x_i, i = 1,2 ... 10,11 to be determined. The range of decision variables is from 0 to 10.

4.1 Initial Parameter Setting

An important component of GA is parameter setting. In this example, the initial population size is set to 40, the crossover rate set to 0.8, and the mutation rate to 0.1. The mating pool is 20, and the daughter generation produced after crossover and mutation is given a population size of ½(20). The next generation population includes the parents of the previous generation (Pareto set of the previous generation and the portion selected by bilateral tournament competition) and their daughter chromosomes produced by mutation and crossover.

OCBA parameters in this example are as follows: initial simulation n0 = 15, $\Delta = 50$, and P{CS} = 0.9.

Table 4 Iterative results of GA_{OCBA}

GA_{OCBA}												
Iteration	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	Total throughputs
1	8	8	8	2	3	8	6	2	10	4	6	31,098
2	3	4	7	4	8	9	7	4	7	7	5	31,650
3	2	9	2	2	7	4	6	3	10	4	1	32,696
4	6	2	3	9	9	6	6	6	6	3	5	32,984
5	6	8	3	3	7	6	6	2	5	9	9	33,201
6	7	6	10	3	10	9	9	9	4	7	4	41,650
7	7	4	9	6	7	5	4	4	5	1	6	42,696
8	9	7	3	3	8	10	2	3	6	5	7	43,742
9	8	5	3	4	10	6	8	9	3	10	5	54,726
10	8	9	7	2	7	4	6	3	4	4	7	65,799
11	8	9	7	2	7	4	6	3	4	4	7	66,789
12	5	10	7	5	5	5	3	3	9	4	7	66,890
13	8	10	7	8	5	7	10	2	10	7	3	69,523

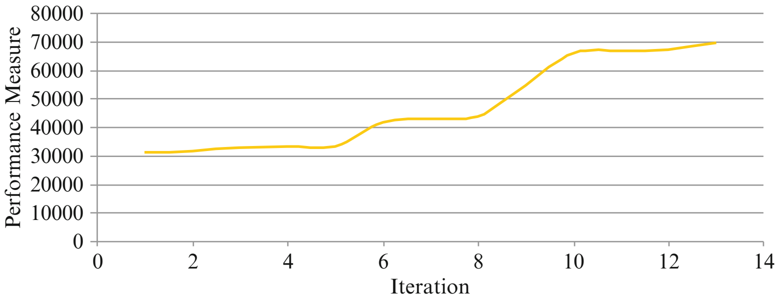

Fig. 5 Progressive improvement of the obtained solution

4.2 *Efficiency of GA_{OCBA}*

Pilot studies showed that system performance will reach a steady state after 30 days. Thus, the performance measure is collected after 30 days of warm-up period and then stored in a data file for analysis. Each simulation was run for another 30 days after the warm-up period. Table 4 provides results of the search process. Initially, five vehicles are allocated for each system (interbay and intrabay). The algorithm iteratively samples ten extra designs, evaluates their promising indexes, and selects the most promising one. As the iteration increases, it gradually converges to the optimal solution (8, 9, 7, 2, 7, 4, 6, 3, 4, 4, 7) with total throughput of 66,890. Figure 5 exhibits the progressive improvement of the obtained solution (vehicle allocation) as the algorithm proceeds. The final solution obtained can deliver more than twice the number of wafer lots compared with the initial solution.

Table 5 provides a further comparison of GA_{OCBA} and GA alone (each iterated 30 times). Incorporating GA into OCBA not only reduced the number of iterations, but

Table 5 Simulation efficiency of GA_{OCBA} and GA

	Generation	Total budget	Simulation time (days)	Improved
GA_{OCBA}	13	9,350	11.69	
GA	19	22,800	28.5	58.99 %

also enabled GA to converge more rapidly. Therefore, for large-scale problems in which the number of alternatives exceeds 200, better design alternatives will emerge if GA searches and OCBA determines the number of iterations.

5 Conclusion

In this study, we presented a simulation optimization model for the vehicle allocation problem in AMHS. The number of loadable vehicles should be determined for distinct system loadings as too few or too many vehicles would impair overall system performance: extended cassette waiting times and low machine utility when the number of transport vehicles is too low, or traffic problems or deadlock when there are too many. This research used a GA with OCBA method to solve large-scale problems involving many alternatives. Through verification via a real-world case, we found that GA_{OCBA} not only reduced the simulation time, but also effectively enabled the GA to converge more rapidly than when using GA alone. This demonstrates that the proposed GA_{OCBA} method may effectively solve large-scale problems and produce adequate design alternatives.

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Comparison with Gender and Postures on Neck Muscle Strength

Bor-Shong Liu, Tsung-Yen Ho, and Wei-Yun Chuang

Abstract Literatures reviewing showed that the long-term abnormal postures caused operators to be suffered the musculoskeletal disorders. Despite the prevalence and cost of neck problems increased, few studies evaluated availably the physical characteristics associated with neck problems. Thus, the measurement method of neck strength had been developed and anthropometric measurements of neck and head had been conducted. Present study had been examined the effects of gender and postures on neck strength and anthropometric measurements of head and neck. In addition, the relationship of anthropometric measurements of head and neck and neck strength had been evaluated. Database of head and neck characteristics could be provided the basis to evaluate the Work-related Musculoskeletal Disorders of neck area.

Keywords Anthropometry • Musculoskeletal disorders • Neck strength • Posture effect

1 Introduction

Review literatures showed that the long-term abnormal postures caused operators to be suffered the musculoskeletal disorders of head and neck areas. Neck-and-shoulder pain and complaints constitute an important public-health problem in western countries [1, 2] and as they account for a large number of working days lost and considerable workers compensation and disability payments [1, 3]. On average, more than half the working population will experience neck pain at least once in their lifetime and about one-third are affected in the course of a year [2].

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Cote et al. [4] reported that 67 % of individuals will suffer neck pain at some stage throughout life. Shoulder and neck symptoms have been linked to jobs with highly repetitive work, static work, and work above shoulder level [5]. Falla [6] presented the recent evidence from laboratory of the complexity of cervical muscle impairment in neck pain patients and in turn will highlight the implications for rehabilitation. Vasavada, Danaraj, and Siegmund [7] based on 14 matched pairs of men and women, and found that most head and neck anthropometric parameters were significantly smaller in females compared to males. Mean flexion strength and extension strength of neck were 149 N, 244 N and 82 N, 173 N in male and female respectively. Moreover, gender differences in a number of neck anthropometry parameters (an average of 9–16 % smaller in females) were larger than differences in head anthropometry parameters (an average of 3–6 % smaller in females). Female necks were also significantly weaker than male necks (32 % weaker in flexion and 20 % weaker in extension).

Neck pain is common in general population, with 70 % of individuals affected at some time in their live. Despite the prevalence and cost of neck problems increased, few studies evaluated availably the physical characteristics associated with neck problems. Thus, the measurement method of neck strength had been developed and anthropometric measurements of neck and head had been conducted. Present study had been examined the effects of gender and postures on neck strength and anthropometric measurements of head and neck. In addition, the relationship of anthropometric measurements of head and neck and neck strength had been evaluated.

2 Methodology

2.1 Participants

Present study recruited 45 undergraduate students at the St. John's University. Their mean age, mean stature and mean body mass were 21.5 years old (SD = 0.95), 163.7 cm (SD = 9.3), and 64.8 kg (SD = 12.6) respectively. All subjects were healthy and reported no musculoskeletal problems that might influence performance detrimentally.

2.2 Neck Strength Measurements

Maximum isometric neck strength in flexion and extension was measured using a hand-held dynamometer (TKK, Japan). For flexion strength, the subjects were lie prone on a mat with arms at their sides, and the force applied to the opisthocranion. The investigator applied a downward force on the glabella through the

Fig. 1 Maximum isometric neck strength on flexion and extension

dynamometer, and the subject was instructed to resist the force while maintaining the head and neck in a neutral posture. Extension strength was measured in a similar manner, with the subject supine with the head and neck extended over the edge and arms folded over the chest. Each measurement continued for approximately 3 s, or until the subject could no longer resist. The subjects rested at least 30 s between trials, and the highest value of three strength measurements was considered to be the subject's maximum strength. Subjects did not exhibit signs of fatigue during the measurements, and maximum strength was recorded in the second or third trial in the majority of the subjects.

2.3 Anthropometric Measurements

A single examiner was used for all anthropometric measurements. Reliability was examined by taking each measurement once a day for 8 days in four different subjects. The resulting intraclass correlation coefficient (ICC) was greater than 0.999. Height and neck length were measured using a Martin-type Anthropometer (TKK, Japan). Head and neck circumferences were measured using a medical tape measure. Height, neck length and all circumferences [7] were measured three times and averaged. Linear dimensions of head and neck were measured once using calipers.

Altogether five anthropometric characteristics were measured (Fig. 1).

(a) Body weight;
(b) Neck width: Medial-lateral dimension of the neck perpendicular to the long axis of the neck above the thyroid cartilage.

(c) Neck depth: Anterior-posterior dimension of the neck perpendicular to the long axis of the neck above the thyroid cartilage.
(d) Neck length (C7): Vertical distance from the C7 spinous process to the tragus of the ear (average of right and left).
(e) Neck circumference: Circumference perpendicular to the long axis of the neck above the thyroid cartilage.

2.4 Data Analysis

All data were coded and summarized using SPSS software for Windows. Analysis of variance (ANOVA) was used to investigate the effects of gender and postures on measurements. Relationships between dimensions were assessed from correlation analysis. In addition, regression analysis had been conducted to predict the neck muscle strength by body weight, neck width, neck depth, neck length, and neck circumference.

3 Results

3.1 Neck Strength Measurements

Table 1 showed the mean strength of neck between genders. The mean extension strength (8.34 kg) was higher than flexion strength (5.51 kg). In addition, results of ANOVA revealed that there were significant differences in both neck strengths between genders ($F(1, 86) = 3.95$, $p < 0.05$). The both mean strength of neck were larger in male than in female.

3.2 Anthropometric Measurements

Table 2 showed that stature, body weight and anthropometric measurements of neck between gender. Results of ANOVA revealed that there were significant differences

Table 1 Measurements neck strength between genders (kg)

Neck strength	Gender	Mean	STD	Min	Max
Flexion	Female	3.79	2.13	1.0	7.3
	Male	6.07	3.79	1.3	17.5
	Average	5.51	3.91	1.0	17.5
Extension	Female	6.59	4.75	1.3	16
	Male	8.91	5.95	2	23
	Average	8.34	5.72	1.3	23

Table 2 Anthropometric measurements between genders (cm)

Measurements	Gender	Mean	SD	Min	Max
Stature	Male	173.12	5.13	165	180
	Female	158.33	2.51	156	161
	Average	169.09	8.21	156	180
Body weight	Male	68.35	14.4	50	120
	Female	52.45	5.84	43	61
	Average	64.47	15.3	43	120
Neck width	Male	9.76	0.79	8	12
	Female	7.69	0.757	6	9
	Average	9.26	1.19	6	12
Neck depth	Male	9.85	0.88	8.6	12.5
	Female	7.75	0.71	6.5	9.1
	Average	9.34	1.24	6.5	12.5
Neck length	Male	11.8	1.98	9.6	15.9
	Female	10.57	0.97	9.4	12.3
	Average	11.5	1.85	9.4	15.9
Neck circumference	Male	36.1	3.25	29.7	44.7
	Female	30.1	1.03	28.3	32.0
	Average	34.58	3.86	28.3	44.7

in stature ($F(1, 43) = 28.9$, $p < 0.001$), body weight ($F(1, 43) = 10.9$, $p < 0.01$), neck width ($F(1, 43) = 57.2$, $p < 0.001$), neck depth ($F(1, 43) = 53.2$, $p < 0.001$), neck circumference ($F(1, 43) = 35.5$, $p < 0.001$) between gender. The mean neck width, neck depth, neck circumference of were larger in male than in female and neck width (9.76 vs. 7.69 cm), neck depth (9.85 vs. 7.75 cm), neck circumference (36.1 vs. 30.01 cm) were for males and females respectively. By contrast, anthropometric measurements of neck length were not significant difference between genders.

3.3 Correction Analysis

There is higher correction between neck strength and body weight (Table 3). For neck of anthropometric measurement, there were higher corrections between neck strength and neck width, neck circumference.

For regression analysis, predicted the neck strength by Body weight, Neck width, Neck depth, Neck circumference as follow:

$$\text{Flexion Strength} = -4.292 + (0.16 \times \text{Body weight}) + (-0.484 \times \text{Neck width}) + (0.076 \times \text{Neck depth}) + (0.095 \times \text{Neck circumference})$$

$$\text{Extension Strength} = -6.169 + (0.157 \times \text{Body weight}) + (-1.35 \times \text{Neck width}) + (1.23 \times \text{Neck depth}) + (0.156 \times \text{Neck circumference})$$

Figure 2 showed that scatter diagram of body weight and flexion strength. While body weight more than 80 kg, the neck flexion strength increased dramatically.

Table 3 Correction analysis

		Flexion strength	Extension strength
Stature	Pearson	.244	.060
	p	.106	.695
	n	45	45
Body weight	Pearson	.664***	.483***
	p	.000	.001
	n	45	45
Neck width	Pearson	.420**	.309*
	p	.004	.039
	n	45	45
Neck depth	Pearson	.446**	.411**
	p	.002	.005
	n	45	45
Neck length	Pearson	−.103	−.266
	p	.501	.077
	n	45	45
Neck circumference	Pearson	.528***	.435**
	p	.000	.003
	n	45	45

Note: *p<0.1, **p<0.05, ***p<0.01

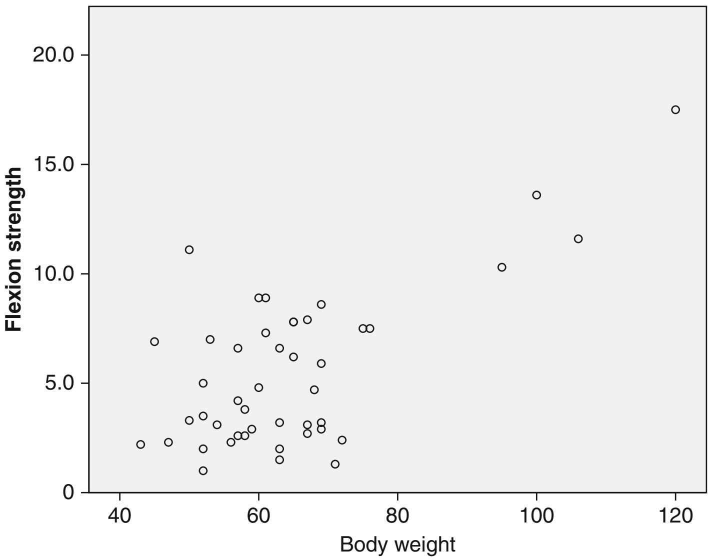

Fig. 2 Scatter diagram of body weight and flexion strength

4 Discussion

In a cross-sectional study of 1,065 visual display terminal workers, the 12-month prevalence of pain in the neck, shoulder, hand/wrist, and elbow/lower arm was 55 %, 38 %, 21 %, and 15 %, respectively [8]. On the other hand, a cross-sectional study of 14,384 workers in an Iranian car manufacturing company showed that self-reported 12-month neck pain was prevalent in only 7 % and shoulder pain in only 6.1 % of the workers [9]. Neck-and-shoulder pain and complaints constitute an important public-health problem.

5 Conclusion

Present study had been examined the effects of gender on neck strength and anthropometric measurements of head and neck. In addition, the relationship of anthropometric measurements of head and neck and neck strength had been evaluated. Database of head and neck characteristics could be provided the basis to evaluate the Work-related Musculoskeletal Disorders of neck area. Further research, health promotion activity such as trampoline sport has been evaluated for head and neck ability of range of motion, muscle force and endurance.

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Improving Green Manufacturing Education in China Universities and Colleges

Li Chen and Qing-chun Xiang

Abstract Green manufacturing is the irresistible development trend of manufacturing industries throughout the world, and green manufacturing education plays an extremely significant part in the process of going green for sustainable manufacturing. In this paper, several typical definitions and meaningful benefits of green manufacturing are firstly introduced, then the situations of green manufacturing education in USA are analyzed for reference to improve the green manufacturing education in Chinese universities and colleges. The indispensable contents of green manufacturing for higher education of Chinese students are summarily presented, involving the related laws and regulations, and some key green manufacturing technologies and methodology such as digital technology, Life Cycle Assessment (LCA), new materials, green energy, near net shape technology, cleaner production, short production processes, automation technology and 6R methodology.

Keywords Green manufacturing • Higher education • Life Cycle Assessment (LCA) • Sustainable development

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1 Introduction

The manufacturing industry has an important role in environmental sustainability by reducing the environmental impact of its manufacturing processes. In recent years, the goal of making manufacturing processes green with less waste and minimizing the environmental impact has become a global trend. This trend is well-known to be green manufacturing, which has become an increasingly important research area to implement sustainable development of local and global economies.

There are several interpretations of green manufacturing, however, all imply the similar meaning. According to Melnyk and Smith, green manufacturing is a system that integrates product and process design with issues of manufacturing, planning and control in such a manner as to identify, quantify, assess, and manage the flow of environmental waste with the goal of reducing and ultimately minimizing environmental impact while also trying to maximize resource efficiency [1]. According to Davim, it is a methodology for manufacturing that minimizes waste and pollution. In other words, green manufacturing is developing energy-efficient manufacturing processes and systems to transform materials in products with reduced emission of greenhouse gases, reduced use of toxic materials, and reduced the generation of waste [2]. According to Tan et al., green manufacturing is defined as an imperative manufacturing strategy for the twenty-first century, integrating all the issues of manufacturing with its ultimate goal of minimizing environmental impact and resource consumption [3]. In essence, green manufacturing is the search for a reduction in the environmental impact of manufacturing activities, without affecting business profitability, gaining the economic benefits, market competitive advantage, and cost savings through waste minimization, resource recovery, and recycling. The main objective of green manufacturing is to support future generations by attaining sustainability, designing and delivering products that minimize negative effects on the environment through their production, use and disposal.

Green manufacturing is also known by different terms such as clean manufacturing, environmentally conscious manufacturing, environmentally benign manufacturing, environmentally responsible manufacturing and sustainable manufacturing.

Green manufacturing can benefit in many ways. Not only will it benefit the environment, but it will impact manufacturing companies, consumers, shareholders, communities, even the globe [4, 5]. Insurance companies are actually giving better rates to manufacturing companies that are taking steps to go green. The government is even offering tax breaks for encouraging manufacturers that have gone green. Renewable energy sources are considered to be one of the fastest-growing job markets. New manufacturing plants with renewable energy sources are offering much more jobs to their communities. It is reported in a recent article on wind power that nearly 400 U.S. manufacturing facilities produced wind turbines and components in 2010, up from as few as 30 in 2004, and an estimated 20,000 U.S. workers were employed in the manufacturing of wind turbines in 2010 [6]. Moreover, it can be said that green manufacturing is not a suggestion but a necessity for mankind's survival.

In China's "National Medium- and Long-Term Science and Technology Development Plan (2006–2020)", it is clearly proposed to actively develop green manufacturing, to speed up the application of product life cycle in materials and product development, design, manufacturing, sales & service, and recycling, to develop high efficient, energy-saving, environmentally friendly and recyclable manufacturing processes for the manufacturing industry of China.

The change to green manufacturing will not happen overnight but over time. Undoubtedly, high education of green manufacturing at universities and colleges for educating tomorrow's workforces plays a significant role in the implementation of green manufacturing. For the undergraduate teaching, green manufacturing education should be improved to strengthen students' green concepts in place of decades of ingrained cognitions, while for the postgraduates, scientific research should be improved to focus on developing green manufacturing processes and methodology. In the disciplines of engineerings, especially in mechanical engineering, teachers should emphasize the concept of green manufacturing throughout the entire professional education.

To improve the green manufacturing education in China, in the paper, the situations of green manufacturing education in USA are firstly analyzed so as to use for reference, then the indispensable contents of green manufacturing for the higher education of Chinese college students are summarily presented.

2 Green Manufacturing Education in USA

In the United States, University of Texas-El Paso (UTEP), Drexel University, Metropolitan State University of Denver (MSU Denver) and the Environmental Protection Agency (EPA) are constructing the models of green manufacturing education for the future [7]. UTEP and Drexel were offered a $2.5 million grant by the Department of Energy for the development of modular learning courses to be shared by the schools. Dr. Devi K. Kalla and Professor Aaron Brown of the Metropolitan State University of Denver incorporate life-cycle assessment teaching to enable engineering and industrial design students to better understand sustainability. They present a course that directs students of MSU Denver to analyze manufacturing processes with an intent to point out areas of adverse environmental impact and minimizing it, to consider alternative processes that incorporate environmental improvements through recycling, substitution of environmentally favorable materials and redesign of processes, to evaluate life-cycles of products and/or processes and propose strategies for minimizing environmental impact while still meeting design and economic requirements, to investigate end-of-use strategies including design-for-recycling tools, to conduct material selection with the goal of reducing the environmental impact of a product and/or process while simultaneously reducing material costs, and to design rules and processes to meet both current market needs and green manufacturing requirements by selecting suitable technical and supply chain management schemes.

The Environmental Protection Agency (EPA) of USA has taken up the green manufacturing education, proposing the Sustainable Manufacturing Curriculum for high schools, career and vocational institutes, community colleges and trade schools. The EPA presents an three-module curriculum: Environmental Sustainability, Lean Manufacturing and Pollution Prevention, and Energy and Carbon. Each module includes a slide presentation and a facilitator's guide with handouts, activities and quizzes. The curriculum modules also include many discussion questions and activities allowing for variable times to implement in the classroom. Educators can pick and choose which topics, discussion questions, and activities best fit their classroom needs.

The Green Enterprise Development (GreenED) workforce training program is established by Purdue University, teaching the latest green manufacturing ideas through a series of in-depth training modules. The three-level program allows learners to earn a green manufacturing certificate once they successfully complete the modules and exam [8]. GreenED is an approved training program in Indiana for this federally funded, state managed job training program, recognized by the Society of Manufacturing Engineers (SME) of USA. Level one of the program is called Green 101, the Green Generalist, which serves as the foundation course for the green initiative, covering the topics like sustainability, solid waste management, energy management and environmental business management. Level two is named Specialist, which is a Green Specialist Certificate Series with six workshops titled "Dumpster Dive", "Energy Management", "Green Chemistry", "H_2O Conserve", "Pollution Solutions" and "Sustainability into Practice". Level three is SME Exam, which includes over 100 questions. The GreenED program offers onsite training, online training, and public workshops.

By comparing the university sustainability education programmes in several European countries and the USA, Peter Glavic [9] summarized that sustainability education had initially focused on specialized offerings first for civil, and later for environmental/chemical engineering programmes. Gradually, the importance of environmental issues was recognized by other disciplines. Teachers from diverse disciplines are now collaborating to develop courses and modify curricula to educate students. According to Peter Glavic, the courses of sustainability education are classified into the following groups of subjects: Pollution control ('end of pipe' solutions, emission abatement, good environmental practice—GEP); Pollution prevention, P2, or cleaner production, CP, (reuse and recycling, waste minimization, zero waste); Resource minimization (encompassing raw materials, energy, and water use as well as process optimization); Green manufacturing (green science, green technology, green engineering, green energy, green systems with sustainable engineering, and industrial ecology/symbiosis); Ecodesign (product and process design, life cycle analysis—LCA, life cycle inventories—LCI, sustainability indicators); Environmental management and economics (ISO 14000 standard series, Environmental Management and Auditing Scheme—EMAS, Best Available Techniques—BAT, Global Reporting Initiative—GRI, Corporate Social Responsibility—CSR, Responsible Care—RC and other Voluntary Environmental Agreements—VEAs; Environmental economics, accounting and financing);

Social topics (environment, health & safety—EHS, environmental education and training, environmental law, environmental policy, sustainable consumption—SC, public relations—PR). He thinks that there are only a few dedicated environmental engineering or environmental science programmes in the undergraduate programmes, and environmental study is most often integrated in other courses, separately available as elective courses in the junior and senior classes, while in the postgraduate study all the universities have courses in environmental science and engineering. He concludes that the most frequent courses are: Water treatment, Waste management, Cleaner production, Energy and environment, Environmental engineering, Optimization methods & processes, Environmental chemistry, Green chemistry, Environmental economics, Environmental management, Environmental law, and good textbooks are not always available for the courses.

From the above analyses, it can be deduced that whether the universities or the administrative departments of USA have paid much attention to the green manufacturing education, and the level of the green manufacturing education in USA is leading in the front ranks of the world.

3 Indispensable Contents of Green Manufacturing Education

The growing body of knowledge on green manufacturing is too vast to cover in this article. Nevertheless, green products, environmentally responsible processes, life cycle methodology, and environmental stewardship need to become the important part of modern education of globally conscious students. They should understand the relationships between the environment, manufacturing industry, citizens, and the government with respect to regulations, science and technology.

3.1 Related Laws and Regulations

Laws and regulations are requiring manufacturers to head toward green manufacturing [10]. Future workforces ought to be educated to know the related local and global legislation on green manufacturing.

Manufacturing in the United States is mostly regulated by four major laws [11]: the Clean Water Act; the Clean Air Act; the Resource Conservation and Recovery Act; and the Comprehensive Environmental Response, Compensation and Liability Act, also known as the Superfund, and their amendments. In addition to these general regulations, each state and some local jurisdictions have similar sets of laws and regulations. The air issues of the future will focus on more stringent regulations on the ground-level ozone, allowable concentration of fine particulate matter less than 2.5 μm (PM2.5), and regional haze. The water issues of the future will be sanitary sewer systems and water treatment plants, and new regulations will set limits for various additional metals in industrial discharge water. The solid-waste issues are administrated with great cost and complexity under the Resource Conservation and Recovery Act. The ISO14040 standard, US EPA Life-Cycle Engineering Standard, and various emerging greenhouse protocols have been implemented.

In China, the ISO9001 quality management system certification, ISO 14001 Environmental Management System Authentication, and OHSMS 18001 occupational health and safety management system certification are implemented by some medium- and large-sized manufacturing enterprises. The main laws for green manufacturing are Environmental Protection Law, Cleaner Production Promotion Law, Air Pollution Prevention Law, Water Pollution Prevention Law, Environmental Noise Pollution Prevention Law, Law of the People's Republic of China on the Prevention and Control of Environmental Pollution Caused by Solid Wastes, Circular Economy Promotion Law, and Energy Conservation Law. Manufacturing companies are also regulated by the Ambient Air Quality Standard, Air Pollutant Emission Standards, Integrated Wastewater Discharge Standard, Surface Water Quality Standards, Emission Standard for Industrial Enterprises Noise, and so on. The most crucial consciousness of manufacturers in China is to strictly abide by the related laws and standards.

3.2 Key Green Manufacturing Processes and Methodology

College students should be taught to understand the key processes and methodology of green manufacturing and the great developments in the manufacturing industry. It is imperative for postgraduates to research and extend the application of green manufacturing technology to save energy and reduce emissions, to reduce impact on the environment and resource consumption in the manufacturing process [12].

3.2.1 Digital Technology

With the rapid development of IT industry, digitization has become the most important methodology to improve the equipment manufacturing industry during the design, manufacture, and end use of products. With the modern digital product development system, the new product development cycle of the Boeing Company has been reduced from 8 years to 5 years. By the virtual reality technology, the simulations for the whole equipment manufacturing process, including product design, processing, machining, operating and recycling, are conducted to greatly improve materials minimization, energy conservation, emission reduction, and cost saving. The technologies of numerical modelling, processing simulation, digital collaborative product development, CNC, rapid prototyping forming, CAD/CAM/CAPP/CAMS, etc. have been extensively adopted in practical industries.

3.2.2 Life Cycle Assessment

Future workforce will need to be educated in green design techniques [13, 14]. One methodology that is particularly attractive to engineers is Life Cycle Assessment (LCA). LCA, including its variants such as process LCA, Economic Input-output LCA and hybrid LCA, is an objective approach to evaluating the environmental burden of a product, process or activity by identifying and quantifying material and energy usage and waste outputs at all stages of the life cycle, from material extraction to product disposal and recycling. Commonly, LCA involves three steps: identification of scope of analysis, life cycle inventory, and impact analysis.

3.2.3 New Materials

The research and application of new materials such as composite materials, light metals, and high temperature alloys, has been transferred from the space and military fields to civil industries, especially for the automotive industry. By using new structural materials, the performance of new generation of airplanes and aircraft engines can be improved 50 70 %, and the weight can be reduced 70 80 %. More than 60 automobile components are made of new magnesium alloys, including clutch housing, transmission housing, steering wheel, seat bracket, panel framework, etc.

3.2.4 Green Energy

There are several green energy sources that can be explored to replace fossil fuels. Fossil fuels have a negative impact on humankind's health, as the burning of these fuels creates fine particle emissions. Some of the several green alternatives include solar, wind and water, all of which are fairly self-explanatory. Geothermal energy is also a viable alternative, which uses the natural heat of the earth to create sustainable energy.

3.2.5 Near Net Shape Technology

Near net shape is an industrial manufacturing technique, by which the initial production of an item is very close to the final shape and size, reducing the need for the traditional surface finishing such as machining or grinding. The near net shape processes include spray forming, rapid prototyping, superplastic forming, injection molding, linear friction welding, high precision forming, internal high pressure forming, and so on. Compared with the forged or welding parts, the hollow structural parts made by the internal high pressure forming process can be reduced 20 30 % in weight.

3.2.6 Cleaner Production

Cleaner production refers to the continuous application of measures for design improvement, utilization of clean energy and raw materials, the implementation of advanced processes, technologies and equipment, improvement of management and comprehensive utilization of resources to reduce pollution at source, enhance the rates of resource utilization efficiency, reduce or avoid pollution generation and discharge in the course of production, provision of services and product use, so as to decrease harm to the health of human beings and the environment. Cleaner production in the green manufacturing process mainly includes clean machining such as dry cutting and laser deburring, clean coating or plating, clean heat treatment, vegetable based cutting fluids, etc. At present, dry grinding is widely adopted in the manufacturing industry of USA, and dry cutting technology is adopted by half of the European manufacturing enterprises. Vacuum coating is now replacing electroplating for automobile wheel hubs.

3.2.7 Short Production Processes

Short production process integrates several processes to reengineer the entire manufacturing process, making full use of materials and energy. The short process smelting technology, combining blast furnace with medium-frequency induction furnace, has been applied to directly produce high-quality complex castings, cutting down the procedures of cooling molten iron from the blast furnace and remelting pig irons. The CNC machining sand molding technology does not need a pattern to form the mold cavity of a casting, greatly shortening the foundry production process. The short production processes also involve laminating object manufacturing (LOM), selective adhesive and hot press process (SAHP), stereolithography technique (SL), selected laser sintering (SLS), three dimensional printing (3DP), etc.

3.2.8 Automation Technology

Automation is the use of machines, control systems and information technologies to optimize productivity in the production of goods and delivery of services. Automation plays an increasingly important role in modern manufacturing processes. Going green can be powerfully driven by adopting integrated automatic control systems and network strategies. Different types of automation tools include artificial neural network (ANN), bonita open solution for business process management (BPM), distributed control system (DCS), human machine interface (HMI), supervisory control and data acquisition (SCADA), programmable logic controller (PLC), programmable automation controller (PAC), motion control, robotics, and artificial intelligence. In recent years, various vision systems have been used for automation, monitoring, quality control and many other manufacturing applications. The Internet of Things technology has become more and more popular in the manufacturing industry.

3.2.9 6R Methodology

Modular design is considered as one of the crucial techniques for product design process which focuses on enhancing 6R abilities (reuse, recycle, reduce, recover, redesign, and remanufacture) through green manufacturing [15]. This 6R methodology is considered as the basic principle of sustainable design and manufacturing, which is composed of six stages of material flow in a product life cycle from its design to its end of life. The recycling and reusing technology aimed to waste-free manufacturing is especially important for heavily polluted industries such as casting, cement, thermal power, and dyeing. Nano-brush plating, nano-thermal spraying, laser cladding, and self-repairing nano-additives have become the key remanufacturing technologies. Remanufactured products provide the same quality and warranty claims as new products, yet at half of the new products' price.

4 Conclusion and Outlook

To accelerate the pace of green manufacturing in China, it is imperative to improve green manufacturing education in China universities and colleges, and is increasingly urgent to cultivate specialized talents of green designing, green processing, recycling and remanufacturing.

By implementing the education of industrial ecology and green manufacturing, the concepts of green engineering, circular economy, cleaner production and delicacy management should be implanted ineradicably into the souls of college students so as to meet the demands of sustainable development. In universities and colleges, green manufacturing engineering laboratories and innovative design research institutions can be established to promote green manufacturing R&D and education. Enterprises should be encouraged and supported by the governments to set up green manufacturing education bases, providing onsite trainings of green engineering practices for college students and improving teachers' practical green knowledges and teaching standards. Public service platforms on green manufacturing can be constructed in universities and colleges to carry out a wide range of green manufacturing advisory services and environmental protection publicity, improving the people's green awareness and ability.

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Modeling Cost-Effectiveness with Energy Saving for Lighting Device Decisions

Earl-Juei Wang and Yin-Kai Huang

Abstract The technical improvement plays an important role in the strategy for the progress of lighting equipment. However, although effective lighting equipment has been significantly progressed in the past two decades, most studies are focused on technical achievement without understanding the cost-effectiveness fundamental to promotional scheme. This article evaluates the functional performance between effective vs. non-effective lighting equipment on cost-effectiveness with energy saving and transformed to equipment carbon reduction by fuzzy multiple objective programming model (FMOP). A number of florescent lamps from market to collect data of costs, functions, use of length, and, their relationship for use in energy consumption, and then applied FMOP to analyze cost-effectiveness. Study results not only compare the energy savings in terms of equivalent carbon emission for the cost effectiveness of lighting equipment selection but also identify the applicability of fuzzy theories for the specific florescent lamp cases and therefore use in subsidiary decision makings for the governmental authorities.

Keywords Cost effectiveness • Energy saving • FMOLP • Lighting equipment

1 Introduction

Lighting accounts for 5–15 % of total electric energy consumption in industrialized countries and 10–25 % in developing countries [1]. Numerous investigations have reviewed pertinent literature on lighting efficiency [2, 3]. Many of the recent ones have focused on issues related to inefficiency and lighting strategy [4]. Because of

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concern for protecting the global environment and increasing CO_2 emissions, saving energy has become a critical issue in the improvement of lighting efficiency. Mahlia et al. [5] stated that the sensible use of electricity in buildings is very important, especially as energy is becoming increasingly expensive. Dubois and Biomsterberg [6] reviewed relevant studies on electric lighting in office buildings. They also discussed strategies for reducing energy use, such as improvements in lamp, ballast and luminaire technology, the use of task/ambient lighting, improvements in maintenance and the utilization factor, and reduction of maintained illumination levels.

Despite carbon reduction problems are receiving interests recently, evaluation for lighting devices linked with cost categories has been little mentioned. Conventional lighting systems valuation methodology usually focuses on the flow of lamp design through technology functions that launch out into practices, followed by efficiency or efficacy to a specific space for use conditions, perhaps passing through a comparison with different technology emergence on the way [7, 8]. Lighting technologies must demonstrate function capability in satisfying user demands and studies have concentrated on performance problems of the designed lamp function [9]. The investigation methodology for lighting systems in energy consumption has been widely applied to satisfy specific national or regional situations [6]. Although previous work has based on the relationship of specific lighting characteristics for different lighting systems by formulating various technology designs, the pre-analysis of economic evaluations as a whole has seldom been mentioned.

The specific objectives are as follows:

1. to analyze the decision components in a lighting device strategy;
2. to devise a multi-period cost-effective model for effective vs. non-effective lighting devices planning and energy consumption; and
3. to develop a fuzzy multiple goal model incorporating lighting equipment selection cost objects.

2 Model Formulation

2.1 *The Proposed MOLP Model*

2.1.1 Nomenclatures

i	Type of fluorescent tube, $i = 1, 2, \ldots, I$.
j	Quantity of lamps required in the specific space, $j = 1, 2, \ldots, J$.
k	Alternatives of lamps; $k = 1, 2, \ldots, K$
t	Lamp use length in unit of hours.
rp	The measure of area.

e Average illumination in a standard of 500 lux.
l_i The luminous flux of lamp type i, $i = 1, 2, \ldots, I$.
l_j Quantity of lamp type j, $j = 1, 2, \ldots, J$.
m Coefficient of maintenance ate 0.6 0.8.
w_i Wattage of lamp set w, $i = 1, 2, \ldots, I$.
p_i Power factor of lamp set, $i = 1, 2, \ldots, I$.
u Coefficient of utilization $u = \frac{reflectivity}{Room\ Index}$.
cl_j Number of required lamps, $cl_j = \left(\frac{rp \times e}{l_i \times u \times m}\right), j = 1, 2 \ldots, J$.
EQ Annual electricity consumed in the planning period, Kw.
α Electricity emission factor.
E_t Equivalent CO_2 emission quantity in period t, $t = 1, 2 \ldots, T$, Kg.
LQ_t *Equivalent* CO_2 emission limit in period t, $t = 1, 2 \ldots, T$, ec_{ijt} Electricity costs in unit of \$, $i = 1, 2, \ldots, I, j = 1, 2 \ldots, J, t = 1, 2 \ldots, T$.
sec_{ijt} Annual saving of electricity cost in unit of \$, $i = 1, 2, \ldots, I, j = 1, 2 \ldots, J$, $t = 1, 2 \ldots, T$.
LC_i Lamp cost for type i, $i = 1, 2, \ldots, I$.
d_{ik} Selective decision for lamp type i with alternative k, where d_{ik} is a binary variable and i=1, 2, …,I, k=1, 2, …,K

2.1.2 Assumptions

1. The use of lamp period is fixed.
2. Lamps installed are batch-replaced at their averages.
3. A lamp-stand is installed and its cost is calculated in the specific lamp alternative at the initial year without replacement during the whole planning period.
4. Either traditional or electronic ballasts are functioning during the planning period.
5. A planning period is designed to be able to include relevant cost payments.

2.1.3 The Objective Functions

Minimizing total costs

$$\begin{aligned}
\text{Min Z} &= \{(\text{replacement cost of fluorescent lamp}) + (\text{quantity of fluorescent lamp} \\
&\quad \times \text{unit cost})\} + \text{electricity cost} - \text{annual electricity cost savings} \\
&= \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K}\left\{\begin{array}{c}\left(cl_j \cdot LC_i\right) + \left[cl_j \cdot l_j \cdot LC_i \cdot (P/F, r\%, t)\right] \\ + \left(ec_{ijt} - sec_{ijt}\right) \cdot (P/A, r\%, t)\end{array}\right\} \cdot d_{ik} \qquad (1)
\end{aligned}$$

Minimizing equivalent carbon emissions

$$\begin{aligned}\text{Min Z} &= \text{quantity of fluorescent lamps} \times \text{annual electricity} \\ &\quad \times \text{emission coefficient of electricity} \times \text{decision of fluorescent lamp type} \\ &= \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K}\left(cl_j \cdot EQ \cdot \alpha \cdot d_{ik}\right)\end{aligned} \tag{2}$$

2.1.4 Constraints

1. Equivalent carbon emissions

Assuming that the function of fluorescent lamps for a specific period t does not change and will continually operate over the planning period T at each time interval, t = 1 … T. Equations (4) and (5) are used to restrain the total equivalent carbon emissions at a certain level and where F_{1t} is used to determine the difference of E_t and LQ_t.

$$E_t = \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K}\left(cl_j \cdot EQ \cdot \alpha \cdot d_{ik}\right), t = 1, 2, \ldots, T \tag{3}$$

$$(E_t - LQ_t) \cdot F_{1t} \geq 0, t = 1, 2, \ldots, T \tag{4}$$

$$(LQ_t - E_t) \cdot F_{2t} \geq 0, t = 1, 2, \ldots, T \tag{5}$$

$$\begin{aligned}&F_{1t} + F_{2t} = 1, t = 1, 2, \ldots, T \\ &F_{1t}, F_{2t} \in \{0, 1\}, \forall t\end{aligned} \tag{6}$$

2. Illumination constraints

Given a specific space, Eqs. (7) and (8) presents that the number of fluorescent lamps must satisfy the range of illumination requirement a b lux, where a and b indicate the range of standard space illumination.

$$a \leq \sum_{i=1}^{I}\sum_{k=1}^{K} e \cdot d_{ik} \leq \mathrm{b} \tag{7}$$

$$rp \cdot a \leq \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K} cl_j \cdot l_i \cdot u \cdot m \cdot d_{ik} \leq rp \cdot \mathrm{b} \tag{8}$$

3. Constraints for illuminance electricity intensity

Equations (9), (10), and (11) are used to restrain the illuminance electricity intensity in terms of electricity consumption, where y_i indicates the choice of fluorescent lamps with illuminance electricity intensity and D is the limit of illuminance electricity intensity. F_1 and F_2 in Eqs. (12) and (13) are used to determine the positive or negative deviation between y_i and D

$$y_i = \frac{w_i \cdot cl_j}{rp} \cdot d_{ik} \leq D \tag{9}$$

$$(y_i - D) \cdot F_1 \geq 0, i = 1, 2, \ldots, I \tag{10}$$

$$(D - y_i) \cdot F_2 \geq 0, i = 1, 2, \ldots, I \tag{11}$$

$$F_1 + F_2 = 1, t = 1, 2, \ldots, T \tag{12}$$

$$F_1, F_2 \in \{0, 1\} \tag{13}$$

4. Non-negativity

$$rp \geq 0, cl_j \geq 0, d_{ik} \geq 0, \quad i = 1, 2, \ldots, I, j = 1, 2 \ldots, J, k = 1, 2, \ldots, K \tag{14}$$

5. Limitations of alternatives

Any fluorescent lamp can only have one choice and will not change in deciding installation setting during the planning period.

$$\sum_{i=1}^{I}\sum_{k=1}^{K} d_{ik} = 1, d_{ik} \in \{0, 1\}, \forall i, k \tag{15}$$

2.2 Linear Membership Functions

The imprecise cost and equivalent carbon emission can be formulated as a fuzzy multi-objective model by applying piecewise linear and continuous functions as follows:

$$f_1(z_1) = \begin{cases} 0 & if\ z_1 \geq z_1^u \\ \dfrac{z_1^u - z_1}{z_1^u - z_1^l} & if\ z_1^l < z_1 < z_1^u \\ 1 & if\ z_1 \leq z_1^l \end{cases} \tag{16}$$

$$f_2(z_2) = \begin{cases} 0 & if\ z_2 \geq z_2^u \\ \dfrac{z_2^u - z_2}{z_2^u - z_2^l} & if\ z_2^l < z_2 < z_2^u \\ 1 & if\ z_2 \leq z_2^l \end{cases} \tag{17}$$

Where z_i^u and $z_i^l (i = 1, 2)$ in Eqs. (16) and (17) represent the upper bounds and lower bounds of domain sets for fuzzy objective function. The solution steps are stated below:

Step 1: Construct the problem as a fuzzy multiple objective model.
Step 2: Define fuzzy objective function $z_i (i = 1, 2, \ldots, k)$ into corresponding linear membership function $f_i(z_i)$.
Step 3: Introduce the auxiliary variable L ($0 \leq L \leq 1$), and transform the original fuzzy MOLP problems into an equivalent crisp LP form by using the minimum operator to aggregate fuzzy sets. The resulting equivalent crisp LP form for solving the fuzzy multi-objective total costs and equivalent carbon emission problem can be then formulated. An auxiliary variable is utilized as minimal operator to integrate each fuzzy set, and covert the original MOLP model into corresponding single objective LP model.
Step 4: Solve the single LP problem and acquire an initial compromised solution.
Step 5: Execute previous four steps and modify relevant parameters until a satisfied solution is achieved.

The original MOLP model can be converted into FMOLP model as below:
The objective function: maximizing satisfaction degree
Max L
Constraints:

1. Satisfactory constraints

$$L \leq \frac{\left(Z_i^u - Z_i\right)}{\left(Z_i^u - Z_i^l\right)}, \forall i \tag{18}$$

2. Equipment carbon emission constraints

$$E_t = \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K}\left(cl_{ij} \cdot EQ_{ijt} \cdot \alpha \cdot d_{ik}\right), t = 1, 2, \ldots, T. \tag{19}$$

$$(E_t - LQ_t) \times F_{1t} \geq 0, t = 1, 2, \ldots, T. \tag{20}$$

$$(LQ_t - E_t) \times F_{2t} \geq 0, t = 1, 2, \ldots, T. \quad (21)$$

$$F_{1t} + F_{2t} = 1, t = 1, 2, \ldots, T. \quad (22)$$

$$F_{1t}, F_{2t} \in \{0, 1\}, \forall t. \quad (23)$$

3. Illumination constraints

$$a \leq \sum_{i=1}^{I}\sum_{k=1}^{K} e \cdot d_{ik} \leq \mathrm{b} \quad (24)$$

$$rp \cdot a \leq \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K} cl_{ij} \cdot l_i \cdot u \cdot m \cdot d_{ik} \leq rp \cdot \mathrm{b} \quad (25)$$

4. Alternative constraints

$$\sum\nolimits_{i=1}^{I}\sum\nolimits_{k=1}^{K} d_{ik} = 1, d_{ik} \in \{0, 1\}, \forall i, k. \quad (26)$$

5. Non-negativity

$$rp \geq 0, cl_{ij} \geq 0, d_{ik} \geq 0, i = 1, 2, \ldots, I, j = 1, 2 \ldots, J; k = 1, 2, \ldots, K \quad (27)$$

6. Satisfactory range

$$0 \leq L \leq 1. \quad (28)$$

3 Implementation

3.1 Problem Description, Data Statement, and Implementation Scenario Design

To demonstrate the application of the developed model, this implementation investigates three market fluorescent lamps, T8/T9, T8 tri-band, and T5. To determine the cost effectiveness of those alternatives, a specific classroom space is designed for the model implementation and the relevant assumptions are as follows:

Items \ Lamp	T8/T9	Tsri-band	T5
Lamp with ballast (S/unit)	690	2100	2800
Lamp (S/unit)	40	90	100
Watt (S/unit)	94	82	62
Hominous flux (lm ‘unit)	6800	6400	5200
Life (hr)	10000	10000	20000
Power factor	48	98	98
Ballast	Traditional	Electronic	Electronic
Annual electricity (kW·h)	3572	3444	3100
Lamp quantity required	19	q21	25
Average illumination	505	518	509
Modified coefficient of electric coax	1.096	0.973	
Discounted rate of lamp		2.46%	
Equivalent carbon emission of electricity		0.623	
Maintenance rate		0.8	

1. Space specifications: 10 M length, 8 M width, 3 M height, and 0.8 M desk height.
2. Space color: white.
3. Length of used hours: 2,000 h per period.
4. Planning length: 40,000 h in terms of 20 periods.
5. A discount rate of 246 % for T5 is used as a comparative base.
6. Levelized initial cost payment for 20 year planning periods is given as (P/A, 2.46 %, t), where t is 5, 10, 15, and 20 years in terms of 10,000, 20,000, 30,000, and 40,000 h respectively.
7. An additional cost payment is required for replacing lighting equipment.
8. The use length of T8/T9 and T8 tri-band is 10,000 h and T5 is 20,000 h. The replacement cost occurred while the use length is reached.

In understanding the applicability of the model to various situations, four scenarios were designed as a basis to demonstrate the effect of replacement cost and the cost effectiveness of high efficient lighting equipment as follows:

1. Scenario 1: none of replacement cost for T8/T9 compared to replacement costs for T8 tri-band and T5.
2. Scenario 2: none of replacement cost for T8tri-bandcompared to replacement costs for T8/T9 and T5.
3. Scenario 3: none of replacement cost for T5 compared to replacement costs for T8/T9 and T/8tri-band.
4. Scenario 4: T8/T9, T8tri-band, and T5 are at the same basis by assuming all lighting devices are newly installed. Regarding the high efficient lighting device, this scenario can be used to evaluate the cost effectiveness of T5 to T8/T9 and T8tri-band.

Table 1 Basic data for space and lamps

Items \ Lamp			T8/T9	T8tri-band	T5
Scenarios	1	Annual electricity costs($/kW·h)	E1	E2	E3
		Annual saving electricity costs	-	E1 – E2	E1 – E3
		Additional cost payment	-	2,100 – 21	2,800 – 25
		Equivalent carbon emission per year(kg)	2,225.356	2,145.612	1,931.300
		Equipment carbon saving per year(kg)	-	79.744	294.056
	2	Annual electricity costs ($/kW·h)	E1	E2	E3
		Annual saving electricity costs	E2 – E1	-	E2–E3
		Additional cost payment	690 – 19	-	2,800 – 25
		Equivalent carbon emission per year (kg)	2,225.356	2,145.612	1,931.300
		Equipment carbon saving per year (kg)	–79.744	-	214.312
	3	Annual electricity costs ($/kW·h)	E1	E2	E3
		Annual saving electricity costs	E3 – E1	E3 – E2	-
		Additional cost payment	690 – 19	2,100 – 21	-
		Equivalent carbon emission per year (kg)	2,225.356	2,145.612	1,931.300
		Equipment carbon saving per year (kg)	–294.056	–214.312	-

Table 1 presents the basic data for the specific classroom space and lamps and Table 2 gives the designed scenarios for implementation.

Table 2 Implementation Results for scenarios 1–4

		Total costs (in unit of Taiwan dollar)		
Time lasting (hours)	Scenarios	T8/T9	T8 tri-band	T5
10,000	1	65,073.57	90,850.94	103,841.2
	2	87,325.27	57,760.22	113,021.0
	3	92,774.10	105,479.6	49,101.77
	4	76,803.30	96,822.12	113,717.9
Accumulated equivalent carbon emission (kg)		11,126.78	10,728.06	9,656.5
20,000	1	122,701.5	133,872.8	138,256.6
	2	153,082.6	108,911.6	155,565.9
	3	163,356.8	161,456.3	96,473.05
	4	134,431.2	147,973.5	152,994.2
Accumulated equivalent carbon emission (kg)		22,253.56	21,456.12	19,313
		Total costs (in unit of Taiwan dollar)		
Time lasting (hours)	Scenarios	T8/T9	T8 tri-band	T5
30,000	1	173,735.7	171,972.2	165,293.1
	2	211,316.1	154,210.2	189,801.6
	3	225,863.6	211,028.2	134,982.1
	4	185,465.4	193,272.1	187,776.6
Accumulated equivalent carbon emission (kg)		33,380.34	32,184.18	28,969.5
40,000	1	218,930.6	205,712.3	192,283.5
	2	262,886.6	194,325.8	223,167.6
	3	281,218.3	254,928.2	172,132.4
	4	230,660.3	233,387.8	221,626.6
Accumulated equivalent carbon emission (kg)		44,507.12	42,912.24	38,626
Electricity intensity: T8/T922.33,T8 tri-band21.53,T519.38				

Table 3 Membership function values

OBJ	Upper	Lower	Difference
Total costs	281,218.3	170,132.4	111,085.9
Equivalent carbon emissions	44,507.12	38,626	5,881.12

3.2 Initial Results

Table 3 summarizes the implementation results for the initial test and the significant findings are as follows:

1. The alternative of T8/T9 holds the cost advantage since the initial year until period 13 (26,000 h) and leaves the solution instead of T5 later on. However, the equivalent carbon emission saving among three alternatives is significant. The alternative of T5 embodies a total of 5,881.12 Kg in equivalent carbon saving than other two alternatives in the whole planning period.

2. Regarding to the additional cost payments, T8 tri-band and T5 have cost advantages in scenarios 2 and 3. This result demonstrates that the cost of replacing lighting equipment may affect the decision.
3. As a practical matter use of high efficient lighting such as T5 fluorescent lamp requires large capital investments, long recovery, and lowering electricity expenses. Use of low efficiency fluorescent lamps such as incandescent or T8 may involve low capital investments and usually having a higher electricity expense. Therefore, the economic decision should be based on the integrated cost categories and should incorporate various restrictions. Scenario 4 shows the implementation results. The alternative of T5 holds the cost advantage to T8tri-band after 24,000 h with a total cost of $167,416.2 and to T8/9 after 30,500 h with a total cost of $189,407.2. The saving of T5 equivalent carbon emission is significant in all time periods.

3.3 Results for FMOP Model

The fuzzy multiple goals are defined by a triangular membership function as represented in Eq. (26). To analyze the sensitivity of decision parameters ((z_1,$f_1(z_1)$), hc, dc, θ), scenarios 3, and 4 were run five times each. The calculation procedure is as follows:

1. Convert the original problem as a MOLP model and define each fuzzy objective function into corresponding linear membership function.
2. Solve the single objective LP model and acquire an initial solution in Table 2 With reference of total costs in 4,000 h, the T5 alternative entered solutions in Scenarios 1, 3, and 4 corresponding to total costs of $192,283.5, $172,132.4, and $221,626.6 respectively. T8 entered the solution in Scenario 2 with a total cost of $194,325.8. Table 3 presents the lower bound and upper bound of membership function values for T5. The difference of total costs and equivalent carbon emission is $111,085.9 and 5,881.12 Kg.
3. Calculate the initial solution for $z_i(i = 1, 2)$ and slightly adjust the upper and lower bounds of membership function for total costs to construct corresponding membership function $f_i(z_i)$ as below:

    1. Membership function for total costs

$$f_1(z_1) = \begin{cases} 0 & if\ z_1 \geq 281,218.3 \\ \frac{281,218.3 - z_1}{281,218.3 - 170,132.4} & if\ 170,132.4 < z_1 < 281,218.3 \\ 1 & if\ z_1 \leq 170,132.4 \end{cases} \quad (29)$$

Table 4 Results for fuzzy implementation

Function \ Lamp membership	T8/T9	T8tri-band	T5
$f_1(z_1)$	0.5607169	0.7822095	0.9819960
$f_2(z_2)$	0	0.2711864	1
Min { $f_1(z_1)$,$f_2(z_2)$ }	0	0.2711864	0.9819960

2. Membership function for equivalent carbon emissions

$$f_2(z_2) = \begin{cases} 0 & if\ z_2 \geq 44,507.12 \\ \frac{44{,}507.12 - z_2}{44{,}507.12 - 38{,}626} & if\ 38{,}626 < z_2 < 44{,}507.12 \\ 1 & if\ z_2 \leq 38,626 \end{cases} \quad (30)$$

4. Execute and modify the steps above until a compromised solution is achieved. The values of two objective functions are Z1 = 172,132.4 and Z2 = 38,626, and the overall satisfaction degree is 0.981996 (Table 4).

4 Discussion

In compliance with the national environmental policy into schools, the lighting technological advancements must be evaluated with attention on their cost-effectiveness. This study provides the linkage of evaluating lighting alternative with lighting alternatives needed either in daily operations or subsidiary policy making.

Costs for lighting selection remain undetermined as new studies continue to neglect the specific requirements of technological advancements. New advancements focus on electric efficiency in terms of the energy savings, clearly ignoring the cost effectiveness employed by schools. Consequently, educational organizations must employ their own strategies to measure the quantity of electric consumption and minimize potential costs. Educational organizations therefore require an alternative analytical model that considers how the electric consumptions impact their lighting selections, given the cost components that result from uncertain technological valuations.

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